THE

AMERICAN JOURNAL OF SCIENCE.

[THIRD SERIES.]

ART. XVIII.—*A Post-Tertiary Elevation of the Sierra Nevada shown by the River beds;* by JOSEPH LECONTE.

[Presented to the National Academy of Science April 24, 1886. Read at Washington, May 3.]

I have on several occasions alluded briefly to the evidences of an elevatory movement in the Sierra at the end of the Tertiary,* but I believe the subject is of sufficient importance to deserve more special treatment. In the present paper I wish not only to give the evidence more fully, but also and especially to correlate this movement with a contemporaneous movement in other parts of the western half of the continent and thus to show that it was very extensive. I wish to show that the upward movement which seems to have affected all high latitude regions at that time, but which was oscillatory and therefore temporary on the eastern side of the continent and in Europe, *on the Pacific side was permanent*, and has largely determined the orographic structure of this side.

* "Old river-beds of California," this Journ., vol. xix, p. 187, 1884. Science, vol. iv, p. 64, 1884. Compend. of Geology, p. 374. Richthofen in his "Natural System of the Volcanic Rocks," p. 86, speaks of an elevation of the Sierra contemporaneous with the lava flood. In fact, according to him the Sierra region was at that time changed from a gently hilly country to a great mountain range. But his reason for so thinking is the supposed existence of the so-called Blue gravel channel running parallel to the range. This channel is now believed to exist only in the fervid imagination of old miners.

River-beds are most important and accurate indicators of crust-movements. On the *margins* of continents coast lines are our indicators; in the interior, where this fails us, we use river-beds and find them equally valuable. This fact was first distinctly brought out and its importance shown by Powell* and afterwards fully elaborated by Gilbert in his monograph on "Henry Mountains" and by Dutton in his monograph on the "Grand Cañon." It is undoubtedly a most fertile principle and of very wide application in Geology. I give here only a very brief statement of the principle as developed by these geologists in order that its application to different regions and especially to the case in hand may be more readily followed.

A river seeks ever to find its *base-level*, i. e., the level at which the tendencies to the opposite processes of erosion and sedimentation balance each other. When this is reached the river neither cuts nor builds up. Suppose then, that a river in its lower course, has reached or nearly reached its base-level. If now the land rises the river immediately begins to cut its bed to lower and lower level until it again reaches its base-level. If on the contrary the land sinks the river will build up by sedimentation until it again finds the level of equilibrium. In the Plateau region, for example, we have the singular phenomenon of a river system running far below the general level of the country; in Holland, on the contrary, we have the converse condition of a river system running above the general level of the country:—in the one case below the feet, in the other above the heads of the people. But both cases come under the same general principle of rivers seeking their base-level. In the one case they seek it by erosion, because the country is rising; in the other by sedimentation, because the country is sinking.

But the above statement requires some modification. In a steady crust a stream never *completely* reaches its base-level in any part because the base-level is constantly changing. The position of the base-level of a stream is determined by the relation of the velocity of the current to the freight of sediment† and the freight of sediment depends on the slope of the upper tributaries. These upper tributaries are always above their base-levels and therefore always cutting and lowering their slopes. But the lowering of the slopes of the upper parts diminishes the freight of sediments and therefore lowers the base-

* Exploration of the Colorado River, p. 203 and seq.

† In a river bearing sediment, the current-energy is consumed partly in carrying and partly in eroding. As the quantity of sediment increases, more and more of the current energy is consumed in carrrying and less and less is left over for erosion, until finally all is thus consumed and the river begins to build by deposit. Thus flooded rivers with rapid current will often build up by deposit, because overloaded, and then afterwards, even with much less current will again scour out their channels.

level of the lower parts of the stream, which therefore also renews its cutting. Thus, as already stated, in a steady crust, even the lower part of a stream never completely reaches its base level, for this is ever being lowered by the lowering of the beds of the upper parts. The only complete limit to erosion—the only final and absolute base-level is, of course, the sea level. But although a river never completely reaches its base-level until it reaches the sea level; yet in a steady crust, it so nearly reaches it in its lower parts that for our purposes we may regard this level as being often practically reached.

Suppose then a country to be raised and then to remain steady. In such case as already explained the streams will cut until in their lower parts they reach or nearly reach their base-level. Now they cut no longer or only at extremely slow rate. As soon as the down-cutting ceases, the stream begins to sweep from side to side under-cutting its banks and widening its channel. But meanwhile the valley slopes on either side and the separating divides are being worn down lower and lower by rain-erosion or weathering. Thus in a country which has remained steady for a long time the topography consists of wide trough-like river-beds separated by low rounded divides. On the contrary, in a country rising or recently risen we have deep, narrow cañons and high, sharp divides, or else high table-lands, between. Therefore deep, narrow cañons are evidence of recent and rapid rising; the *deeper* the cañon the more *rapid* has been the rising. But since the widening is meanwhile also progressing, the *narrower* the cañons, the more *recent* has been the rising.

We have seen that the more rapid the rising, the more rapid the cutting; also that after a while if the crust remains steady, the cutting ceases and the divides are lowered. It follows therefore that the depth of river cañons cannot be taken as a measure, even a rough measure, of time; (1) because the rate of cutting is so greatly dependent on the difference between the actual river-bed and the base-level, and (2), because when the deepening ceases the lowering of the divides still continues and the cañons are thenceforward lessening in depth. Therefore so far from deep cañons being evidence of geologically long work, the very reverse is true, viz: wide, shallow river-beds are characteristic of old topography.

Again: we have seen that if a country rises and then remains steady the rivers will cut to base-level and stop cutting—the channels will stop deepening and will only widen. If now another rise commences the rivers will cut again, making an inner and narrower gorge. Thus successive risings may be recorded in successive benches more or less marked.

Application of these Principles.

1. *Plateau Region.*

This remarkable region, as is well known, is intersected by profound cañons which are among the wonders of the world. The reason is, that it has been rising in comparatively recent times and faster than the rivers could cut. But that the rising has not been continuous and at uniform rate, is proved by the structure of the Grand Cañon as shown in the figure (fig. 1).

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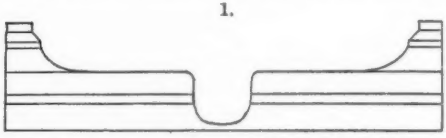

Ideal section across Grand Cañon. After Dutton.

It consists, as seen, of two cañons, one within the other. The outer cañon is 5–6 miles wide, the inner only about $\frac{3}{4}$ of a mile wide, or about as wide as deep. This inner gorge is much the more recent and therefore has not yet had time to widen out.

The history of the plateau region, as recorded in the Grand Cañon according to Dutton, is as follows: At the end of the Eocene this region was first laid bare by the draining of the great Eocene lakes, and the present river system was established. During the whole Miocene there was a continual arching of the earth-crust in the region, with consequent rising of the country and proportionate erosion over the whole area. This however is recorded rather in the erosion cliffs which characterize this region, than in the cañons proper. At the beginning of the Pliocene a more rapid rising commenced and the outer cañon began to form and continued to deepen as the land rose. Then the rise ceasing the river gradually reached its base level, the cañon ceased to deepen but continued to widen until the outer cañon reached nearly its present condition. Then later, viz: at the beginning of the Quaternary, the land began again to rise, and the river again to cut rapidly and has since that time cut the inner gorge. It is probable that the rising, and certain that the deepening, still continues.

Outside of the Grand Cañon northward there is a succession of regular tables 10–20 miles wide, terminated by irregular E. and W. cliffs 1000–2000 feet high (fig. 2). All these cliffs are now receding by erosion. If the arching strata be restored the amount of erosion is seen to be enormous. According to Powell the average thickness removed on the whole area is 6000–8000 feet, and the extreme thickness on the highest part

10,000–12,000. Besides this, the Grand Cañon is itself 6000 feet deep, making an extreme erosion of 18,000 feet; and taking the bottom of the Grand Cañon at 2000 feet above sea-level, it makes the whole rise during the Tertiary (for this whole region was sea-bottom during the Cretaceous) at least

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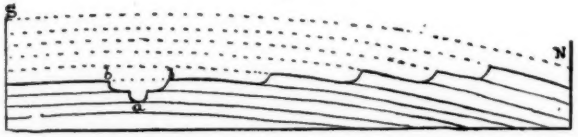

Ideal section across the Grand Cañon, showing the successive erosion-cliffs to the northward. The dotted lines show the amount of erosion.

20,000 feet. The outer cañon walls *b b* may be regarded as commencing cliffs, or the successive cliffs as far-receded and therefore very old cañon walls: although the forms are certainly unique in this case. The exceptional verticality of the widening cañon-walls is the result partly of the very gentle outward dipping of the strata composed of alternate hard and soft material, and partly of the air and climate, and the absence of vegetation to hold the soil and humus to decompose the rocks.

2. *Rivers of the eastern drift region.*

Over the whole area of the drift region in the eastern part of the continent we have, as is well known, the reverse condition of things. The rivers there have sought their base-level by sedimentation instead of erosion, because the land has subsided from a previous more elevated condition. Beneath the present river-beds in all this region we find much deeper and wider beds, now filled with drift or with old river deposits, as shown in the ideal section, fig. 3. In this figure the wide

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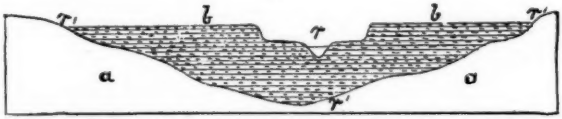

Ideal section across a river bed in Drift region. *r*, Present river bed; *r' r'*, old river bed; *a*, country rock; *b b*, old river sediment.

river bed *r' r' r'* is the tertiary and *r* the present river bed. This relation between the old and present river beds shows that in later Tertiary and early Quaternary times the land was higher than now, and the rivers cut to their base-level; and that this state continued a long time until the channels had

widened out. Then during the later Quaternary (Champlain epoch of Dana) the land subsided and the rivers seeking their base-level by deposit filled up the old channels to their brims. Then lastly during the transition to the present (Terrace epoch) the land rose again and the rivers began again to cut; but the late Tertiary elevation has not yet been reached by the land nor the old beds by the rivers.

In the case of the Mississippi river we find as I think the record of still another movement in the opposite direction, i. e. subsidence, in still more recent times. This is shown by the upbuilding again of the river-bed by deposit of recent alluvium to an average depth, according to Hilgard, of 50 feet. Fig. 4 is an ideal section across the Mississippi showing these facts. After what we have said the record of this river is easily read.

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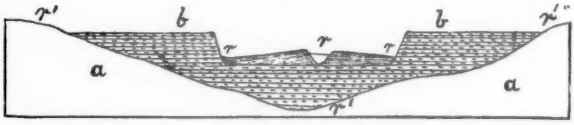

Ideal section across the Mississippi river and bluffs. *r r*, Present river bed; *r' r' r'*, old river bed; *a*, country rock; *b b*, old river sediment.

1. The old bed *r' r' r'*, 100 miles across, was formed during a more elevated condition of the land in late Tertiary and early Quaternary (Glacial) times. 2. In later Quaternary (Champlain) this was filled to the brim with deposit 400 or more feet thick, because the land was then subsided and probably also because of more abundant sediment. 3. During the Terrace epoch the land rose and the river cut until the present wide channel *r r*, 10 miles wide and bounded by bluffs 200 feet high, was formed. This wide channel is not the result, however, of ordinary cliff recession as in the case of the Grand Cañon, for there has been neither time enough to produce such width nor suitable material to develop by recession such perpendicular forms; but it is due to the shifting of the great river from side to side and undercutting the bounding bluffs. 4. Lastly, during the present epoch there has been some subsidence again and a refilling to the extent of 50 feet by the alluvium. Other evidences of this last subsidence are found in old buried forest grounds in the delta, far below the present sea-level.

The phenomena of European river-beds are substantially similar to those of eastern North America in the drift-region.

River-beds of California and the evidences of Sierra-Elevation.

All that I have thus far said is introductory to this the main subject. It is well known since the publication of Whitney's

Geological Survey, that there is a peculiar, almost unique relation of the old to the new river-beds in middle California. At the end of the Tertiary period the then existing river-system was obliterated by an immense flood of lava which, issuing from fissures in the high Sierra, flowed westward down the river-valleys filling them completely and displacing the rivers. The displaced rivers, of course, immediately set to work cutting new channels mainly on the intervals or low divides between the old channels, because there the lava was thinnest or absent altogether. Since that time the rivers have cut beds 2000 to 3000 feet *below the level of the old beds*. The relation between the old and new beds is shown in the figures (figs. 5 and 6) in which r' r' represents the old Tertiary beds and r r the present beds. Sometimes the lava is hard basalt and erosion then gives rise to table-mountain forms as in fig. 5. Sometimes it is softer, as ash, tufa, etc., and thus erosion-forms are rounded as in fig. 6.

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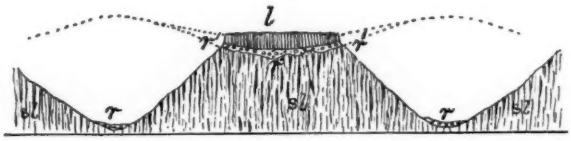

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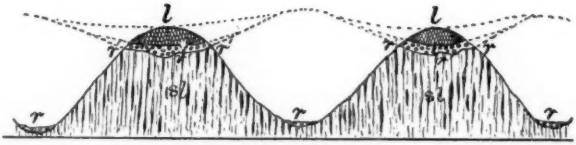

Ideal sections across river beds in middle California. In fig. 5 the lava is basalt, in fig. 6 tufa. *r*, Present river bed; *r' r'*, old river bed; *l*, lava; *sl*, slate.

Now what we wish to emphasize, is that the lower position of the present river beds is not the result of longer time of cutting (for the time has been very much shorter), but of more rapid work—that this position is demonstrative proof that a very great increase in the height and angle of slope of the Sierra took place contemporaneously with the lava flow at the end of the Tertiary or beginning of the Quaternary. The old river-beds were probably established at the beginning of the Cretaceous when the Sierra range was born from the sea, and were being cut and shaped throughout the whole Cretaceous and Tertiary. By the end of that time they seem to have been broad, shallow troughs with low divides between as shown by the dotted lines in figs. 5 and 6. The rivers seem to have reached their base-level and had ceased to deepen their chan-

nels, but rain-erosion still continued to widen the valleys and cut down the divides. The river-system had therefore assumed the form characteristic of old topography. Then came the lava flood displacing the rivers, and the contemporaneous elevation changing the base-level and enormously increasing the erosive power of the rivers. These therefore without loss of time, commenced cutting anew and in comparatively short time have cut far lower than before. And because they have worked rapidly and are still working, the cañons are deep V-shaped. The Tertiary rivers were working during the whole Cretaceous and Tertiary; the present rivers only during the Quaternary and present. The working time of the former was many times greater than that of the latter; and yet the present rivers have cut much deeper. It is impossible to explain this except by supposing a great rise, probably several thousands of feet with increased slope of the range, at the end of the Tertiary.

This Post-tertiary elevation of the Sierra extended far beyond the limits of the lava-flood. The lava-flood was a concomitant, possibly a result, not the *cause* of the elevation. In Southern California beyond the limits of the lava-flood we have equally convincing evidence of great elevation at this time. Here the rivers were not displaced—they continued to occupy the same places, but commenced to cut deeper at that time. The evidence of this is found in the fact that remnants of the old river-gravels are now found clinging high up on the slopes of the present cañon-sides. The relation of the old to the new river beds in Southern California is shown in the ideal section, fig. 7, in which the letters indicate the same as in previous figs. I first observed this during the summer of 1883 in

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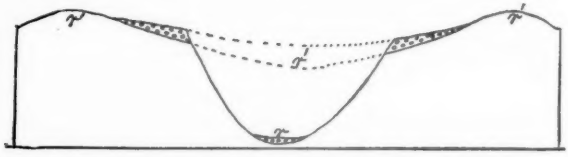


Ideal section across a river bed in Southern California. r, Present river bed; r' r', old river bed.

Lytle Creek Cañon where the old gravels high up on the sides of the present cañon-walls have been worked for gold with indifferent success in several places. I visited and examined them carefully. I have heard of a similar relation in other places but have not examined them. There can be no doubt therefore that the elevation extended the whole length of the Sierra. The maximum was probably in the region of the

highest summits and deepest cañons, viz: about the head waters of the King and Kern rivers.

The relation of the Tertiary to the present river-beds is unique only in *middle* California, because there the lava-flow was sufficient only to fill up the valleys, not to cover deeply the divides. On these divides therefore the rivers located their new channels. Farther north the lava-flood was so deep and universal that either the rivers have not been able to cut through, or if they have, there is no definite relation of these channels to the old channels. Farther south the lava did not extend and the rivers were not displaced.

Contemporaneous Movement in the Plateau and Basin Regions.

We have already seen, p. 170, that the inner gorge of the Grand Cañon was formed by a second elevation of the Plateau region, and that according to Dutton, this movement took place at the end of the Tertiary. It is almost certain then, that it was correlated with the Post-tertiary elevation above insisted on. The new river-cañons of mid-California, the deeper portions of the cañons of Southern California, and the inner gorge of the Grand Cañon are contemporaneous and produced by the same general movement. The movement in the Sierra was accompanied by a prodigious outflow of lava. In the Plateau region it was attended by the formation of a system of N. and S. fissures several hundred miles long, breaking the crust of the earth into huge oblong blocks which, settling unequally, have given rise to those wonderful N. and S. *displacement*-cliffs which equally with the E. and W. *erosion*-cliffs (p. 170), are a characteristic feature of the region. It was attended here also with outflows of lava, but on a lesser scale than in California. It was attended also with a readjustment, if not the formation, of the great fissures and faults of the Basin region. In connection with the elevation of the Sierra, the great fault-scarp on the east side of the Sierra was doubtless increased. The same is true of the fault-scarp on the west side of the Wasatch range. The elevation therefore was not only general over the whole region, but also local, i. e. greater along these ranges.

Contemporaneous movements in Southern Oregon.

The Basin region, as long ago shown by Gilbert and Howell*, is affected by a system of N. and S. fissures breaking the crust of the earth into oblong blocks, which in settling have been mostly tilted so as to give rise to a series of monoclinal N. and S. ridges. This is well shown in the following fig. (fig. 8) taken from Howell. We have already said these were pro-

* Wheeler Survey, vol. iii.

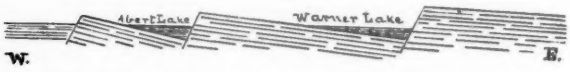
duced at the beginning of the Quaternary—we now proceed to give further evidence.

Mr. Russell, in a recent very excellent and suggestive paper on Southern Oregon,* has shown that the country rock of this region consists wholly of successive sheets of lava several thousand feet thick, originally level, but now broken by N. and S. fissures into oblong blocks, which are mostly tilted in such wise as to produce a series of faults, the uplifted sides forming ridges while on the downthrows have accumulated *lakes*. This is shown in fig. 9. In all cases the faults are normal, and therefore when the fissures dip in opposite directions, the wedge-shaped blocks thus produced may drop bodily down, or be raised bodily up, as shown in fig. 10, according as the base of

8.

Section showing Basin region structure. After Howell.

9.



Sketch sections across Warner valley. After Russell.

10.

Sketch section across Stein Mts. After Russell.

the wedge is upward or downward. We have in this region therefore, on a smaller scale but in very simple and perfect condition, the characteristic Basin structure, except that only in this case the country being in the region of the great lava-flood, the broken and displaced layers are lava-sheets instead of sediments. As to the age of these faults, although he acknowledges some discrepancy in the evidence derived from vertebrate and invertebrate fossils, Mr. Russell decides with great positiveness that the old or enlarged lakes of which the present lakes are the residues belong to the same period as Lake Lahontan and Lake Bonneville, i. e. to the Quaternary. The fissures were therefore formed and the displacements commenced at the beginning of the Quaternary, doubtless by the same orographic movement which so greatly increased the elevation of the Sierra.

I have referred above to the supposed discrepancy between

* U. S. Geol. Rep., 1882–'83, p. 435.

the evidences of the age of the enlarged lakes as derived from the vertebrate and the invertebrate remains in the lake deposits. The latter are the same as those of L. Lahontan and are all living now in rivers of California. The former are the mammoth, camels, gigantic edentates, horse, etc., and are referred by Marsh to the Equus beds of the uppermost Pliocene. These vertebrate remains are all on the surface and underlaid by the recent shells, and Mr. Russell thinks they may have been drifted in from older, i. e. Pliocene deposits; for the testimony of the invertebrates (shells) seems conclusive. But in any case the mammoth, the gigantic edentates and the modern horse are placed by nearly all authorities in the Quaternary. If we reject Quaternary as a distinct period, and have only Tertiary and Recent, these animals may well be put in the uppermost Pliocene instead of the Recent. But if we are to have a Quaternary or transition between the Tertiary and the Recent, then all these animals more properly belong to the Quaternary.

Relation of the Post-Tertiary movement to the Great Lava-flood.

The great Lava-flood of the Northwest, which covers an area of 200,000 square miles, and where cut through by the Columbia river, at the Cascade, is between 3,000 and 4,000 feet thick, probably *commenced* to be outpoured at the beginning of the Pliocene epoch.* The evidence of this is not entirely conclusive. All we know for certain is that it is immediately underlaid by, and was therefore outpoured upon, eroded strata of Miocene age. It is almost certainly, therefore, Post-miocene. But the fact that great orographic movements over the whole western half of the continent occurred at the end of the Miocene (viz: the increased elevation of the Plateau region and the cutting of the outer Grand Cañon, and the letting down of the Basin region on the one side and the Plains region on the other, with the great increase of the size of the lakes in these regions; and especially the formation of the coast ranges of Pacific coast), makes it very probable that the great lava-flood was associated with these movements and commenced at the same time. But if so, it probably continued by successive fissure eruptions through the whole Pliocene, and by volcanic eruption almost to the present time. Certainly the great flows of California were as late as the end of the Pliocene.†

* "Great Lava-flood of the Northwest," etc., this Journal, vol. vii, p. 177, 1874. Mr. Russell in his paper on Southern Oregon, p. 451, quotes me as referring the lava-flood to the Miocene. The *underlying strata* are Miocene. The lava is probably Pliocene.

† Mr. Ross Browne of the University of California, from very careful survey of one of the old river beds of California finds evidence of several lava-flows, one above another separated by gravels, but the greatest, and that which displaced the river, was the latest.

Relation of the Post-Tertiary movement to the great fissures and normal faults of the West.

In the Basin region, Mr. Russell and others have drawn attention to the entire distinctness in time and in character, of the forces which crumpled the strata (mountain-making forces) and those which produced the fractures and faults, and therefore which determined largely the present orographic structure; the latter being much more recent. The former took place at the end of the Jurassic, the latter probably at the end of the Tertiary. So also in the Sierra range, we must distinguish betwixt the orogenic forces which crumpled the Carboniferous, Triassic and Jurassic strata lying on its flanks and that much later movement which greatly increased its height and determined its present slopes and which caused the rivers to cut the present cañons so deep. The former, as Whitney has shown, took place at the end of the Jurassic, the latter as we have seen, at the end of the Tertiary. The Sierra as we now know it, both in height and in scenic configuration, is largely due to this latter movement.

Furthermore, it seems probable, nay, almost certain, that those great fissures which break the crust of the earth into blocks which by unequal settling give rise to normal faults, were produced not at the time of orogenic crumpling, but subsequently. Mountain ranges are in the first instance formed by horizontal pressure crumpling and upswelling thick sediments on marginal sea-bottoms;* but these sediments being comparatively soft, yield easily, and may be mashed together with little fracturing; or if there be fractures, these give rise to *reverse* faults, i. e. a pushing of the hanging wall over the foot wall, the extreme forms of which are the over-thrusts and horizontal shearings described by Geikie and Peach in the Scottish highlands.† But after the crust has again become rigid, bodily movements of a somewhat different kind, and the cause of which we still very imperfectly understand, give rise to fractures which by *gravitative settling* produce *normal* faults so common everywhere. It is certain that the great normal faults which characterize the Basin region, among which must be counted the Eastern Sierra fault and the Western Wasatch fault, were produced in this way long after the orogenic crumpling had ceased. It is certain, also, that the prodigious faults which characterize the Plateau region, where there was no orogenic crumpling at all, were formed in the same way. Is it not probable then that the fissures of the Sierra also, which by filling with mineral matter have formed its metalliferous veins,

* Theory of formation of great features of Earth Surface, this Jour., vol. iv, p. 345 and p. 460, 1872.

† Nature, vol. xxxi, p. 29, 1884.

were formed not at the time of the birth of this range, but rather during its growth in the Cretaceous, Tertiary, and even at the end of the Tertiary?

Evidences of still more recent movements.

All the fault-movements spoken of above have been going on apparently even to the present time. We have abundant evidence of this in the great Wasatch fault as shown by Gilbert* and in the faults of the Basin region and especially of Southern Oregon as shown by Russell.† With every readjustment and increase of fault there is probably an earthquake. The great fault on the eastern side of the Sierra and therefore the elevation of the crest of this range has increased in very recent times and is still increasing. The great Inyo earthquake of 1872 was certainly accompanied and probably *caused* by a notable (25 ft.) increase of this slip along a distance of 40 miles.‡ This is by far the most probable cause of most earthquakes. We may conceive forces, of the nature of which we know little, elevating slowly one side of a fissure, usually a mountain range, and the other side dragged up also by adhesion, a little way, say 10 to 20 feet, until finally the lower side drops and produces an earthquake. If then the Sierra is still rising, the rivers must be still cutting. The shape of the cañon confirms this conclusion.

Observe, then, that the Post-tertiary rise of the Sierra was not a continental movement merely (for this would not have increased so greatly the slope); nor was it orogenic crumpling and up-swelling; but it was elevation of the crest with large increase of the eastern fault-scarp. It is impossible to overlook the connection of this great increase in the height of the Sierra with the progressive desiccation of the Basin region which commenced at this time.

Contemporaneous Elevation of the west side of South America and subsidence of the mid-Pacific bottom.

We have thus far spoken only of elevatory movements on the west side of the *North* American continent; but a similar movement seems to have occurred at the same time and on a still grander scale on the west side of the South American continent also. This is shown by the well known beach lines traced by Darwin up to 1200–1500 feet above present sea level, and

* History of L. Bonneville, Report of U. S. Geol. Surv. for 1880–81, p. 170.

† History of L. Lahontan, Report of U. S. Geol. Survey, 1881–82, p. 195, and Reconnaisance of Southern Oregon, Report of U. S. Geol. Survey, 1882–83, p. 435.

‡ Several writers have lately spoken of the readjustment of this fault as the cause of the Inyo earthquake. I believe that the first mention of this was in my article on Origin and Structure of Mountains, this Journal, vol. xvi, p. 101, 1878.

still later by recent corals found by Alex. Agassiz 2900 feet above the same level.* It is evident then that the whole western side of the two Americas participated in this upward movement. Now so great and extensive an elevation must have had its correlative in corresponding subsidence somewhere. Where shall we look for it unless in the Pacific bottom? The observations of Darwin and Dana on the phenomena of Coral reefs have long been regarded as demonstrative proofs of such a subsidence over an immense area (at least 10,000,000 square miles) in mid-Pacific. It is true that the "Subsidence theory" of the origin of barrier reefs and atolls has very recently been seriously questioned by Mr. Murray† and others, but it must still be regarded as the probable explanation. Barriers may certainly and atolls possibly be formed without subsidence, but subsidence is probably the most common cause.‡ The fact of the recent continental elevation on the Pacific side of the two Americas is additional presumption in its favor. If so, then, it is probable that the down-sinking of mid-Pacific floor, the elevation of the whole western side of the two Americas, the prodigious erosion and cañon-cutting of the Plateau region, the deep V-shaped cañons of the Sierra and the great N. and S. fissures and normal faults of the Basin and Plateau regions are all closely related to each other. Moreover the movements which determined these phenomena were all in progress from the beginning of the Tertiary, reached their greatest intensity in early Quaternary and are still progressing.

Cause of these movements.

In these latter times there has been a tendency to regard elevation and subsidence when unattended with plication, as a simple matter of equilibrium of a floating crust. According to this view, wherever abundant sedimentation is going on, there the crust weighted down by the increasing mass subsides *pari passu*, and wherever erosion is exceptionally active as in great mountains and high plateaus, there the ever lightening crust rises *pari passu*. Thus subsidence and elevation are caused by weighting and lightening.§ Doubtless this is a real cause which must not be neglected, but it cannot be the principal cause. Doubtless the proposition is true, but the converse proposition is much more true, viz: that subsidence is the cause and necessary condition of sedimentation, and elevation the cause of exceptional erosion. The plateau region, for exam-

* Proc. Am. Acad. Sci., xi, p. 257, 1876.

† Nature, vol. xxii, p. 251, 1880, and vol. xxxiii, p. 202, 1885.

‡ Dana, this Journal, vol. xxx, p. 89 and 169, 1885.

§ Nature, vol. xxvii, p. 523; vol. xxviii, pp. 323, 365, 388, 488–539, 587; vol. xxix, p. 212. Geol. Magazine, vol. x, pp. 302 and 348, 1883.

ple, during the Carboniferous, Permian and whole Mesozoic times was a region of subsidence to the extent of 15,000 feet* (for such is the thickness of these strata there). Since that time it has been a region of elevation and has risen probably at least 20,000 feet. But the extreme *general* erosion (i. e. leaving out the cañon-cutting) has been only about 12,000 feet, leaving the region still 8000 feet high in its highest parts. Now first, why did the rise commence at all? and 2d, how can a lightening by removal of 12,000 feet cause an elevation of 20,000 feet? In fact at every step the erosion has lagged behind the elevation, as it ought, if it be effect. The fundamental cause of subsidence and elevation over great areas must therefore be sought elsewhere, although doubtless weighting and lightening, by adding to the force or lessening resistance, will cause these movements to go farther than they otherwise would. This is but an example of reaction of effect on cause, of which we find so many in all cases of complexly related phenomena. As to the real and fundamental cause of the oscillatory crust-movements we are not yet prepared to speak with any certainty. We must wait for more light.

ART. XIX.—*The Strain-effect of Sudden Cooling as Exhibited by Glass and by Steel;* Second Paper;† by C. BARUS and V. STROUHAL.

IN our last paper‡ we compared the strains experienced by glass and by steel on sudden cooling, by aid of the density variations observed when the bodies carrying strain were annealed, *as a whole.* In this paper we desire to substantiate and to give sharper expression to our earlier inferences relative to the temper-strain in glass. To do this we repeat Professor Rood's experiments on the polariscopic effect of continuous annealing of cooled glass, at low temperatures. Our second purpose in this paper is to investigate the density relations of consecutive similar shells of the Prince Rupert drop, and the optical character of the successive cores. Availing ourselves of all the evidence adduced in our investigation at its present stage, we endeavor in general to show that the optical effect of the temper-strain in glass may be regarded as the analogon of the electrical effect of the temper-strain in steel.

* Powell, 2d Report of U. S. Geol. Survey, Introduction, p. xv.

† Communicated with the permission of the Director of the Geological Survey.

‡ This Journal, III, xxxi, p. 439, 1886.

Certain general properties of the Prince Rupert drop.

It is well known that mere breakage of the tail of a P. R. drop is sufficient to shatter it; that the splinters fly apart with explosive violence. It is not so well if at all known, that the same drop may be dissolved in hydrofluoric acid to a mere spicule without exploding. This peculiar behavior calls to mind certain properties of nitroglycerin, inasmuch as this substance may be burned off quietly in a wick, but explodes on percussion. It is in keeping, moreover, with a friend's* ingenious suggestion that in the quenched globule we may possibly encounter a polymerization of the molecular structure of the annealed globule. The fact that the strain in question is of an ordinary mechanical kind seems proven, however, by the observations of Table I, in which the behavior of P. R. drops from which different thicknesses of shell have been removed by solution, is described. Diameter refers to the mean transverse thickness of the drops; ϑ and μ to the thickness and the mass, respectively, of the dissolved shells. After removing a sufficient depth of shell, the residual explosive properties were tested either by crushing the reduced drop, longitudinally, in a vise, or by striking in the same direction with a hammer.

TABLE I.—*Explosive tendency of P. R. Drops.*

No.	Minutes in HF.	Diameter.	ϑ	μ	Remarks.
		cm	cm	g	
12	0	0·848	0·006	----	Shattered on breaking base of tail.
	5	0·835			Explosive tendency diminished in marked degree.
10	0	0·796	0·015	----	Shattered on being split longitudinally. Fragments partially cohere.
	10	0·766			
11	0	0·795	0·017	----	Shattered on being split longitudinally. Fragments partially cohere.
	14	0·760			
13	0	0·774	0·031	0·291	Shattered on being split longitudinally. Fragments more cohering.
	30	0·712			
3	0	0·795	0·054	0·492	Is not shattered on splitting. Conchoidal fracture.
	--	0·688			
5	0	0·825	0·053	0·491	Is not shattered on splitting. Conchoidal fracture.
	--	0·720			
7	0	0·763	0·112	0·722	Is not shattered on splitting. Conchoidal fracture.
	--	0·539			
8	0	0·791	0·117	0·752	Is not shattered on splitting. Conchoidal fracture.
	--	0·557			

The Table shows that the explosive tendency of the P. R. drop becomes rapidly less pronounced as the thickness of removed shell increases; that this tendency is very perceptibly

* A precautionary suggestion for which we are indebted to Dr. Gooch.

impaired by the removal of less than one-tenth millimeter of shell; that it vanishes almost wholly with the removal of one-half millimeter of shell. If the radius of the drop be diminished about 0·03^{cm} the particles of the fractured globule frequently cohere, and the original structure may then be inferred from the general direction and distribution of the fissures. The arrangement of the individual fragments is quite characteristic; they are found to be flat irregular conoids, with their apices toward the line of symmetry of the drop, their bases in its surface,—an arrangement something like the eye of an insect, or even more like the fruit cone of a spruce tree. In other words the radial structure of the fissured P. R. drop is distinctly marked. This proves that the original (unbroken) drop must have possessed a box-within-box structure; that if the bubbles were symmetrically disposed, particles similarly situated with reference to the line of symmetry would be in like states of strain. But the law according to which matter is distributed from circumference to axis cannot be inferred, since the stated phenomena follow equally well both for surface dilatation and for surface compression.

All the P. R. drops examined were found to scratch ordinary glass with facility; but on taking the strain out of the drops by annealing them at white heat and slow cooling, their hardness did not materially change. The observed hardness was therefore a property of the glass itself. Indeed by rubbing together a quenched and an annealed P. R. drop a difference of hardness could not be discerned with certainty.

Polariscopic Observations.

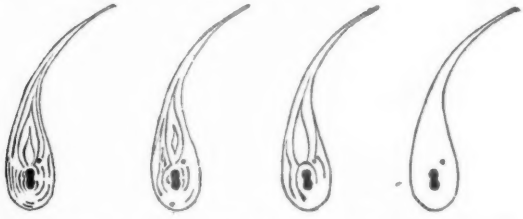
Annealing.—Our object in this place is merely to detect variation in the polarization figure, produced either by removal of shells or by annealing. It is therefore sufficient to examine the drops in a given fixed position between polarizing plates.* Disturbances due to diffuse refraction are satisfactorily eliminable by submerging the P. R. drop in glycerin, the refractive index of which is nearly that of the glass. The demarcation is then distinct and the colors clear, so that the figures can be drawn. The necessity of grinding special plates is thus fortunately obviated; applied to a quenched P. R. drop the operation would not, of course, be feasible.

In the case of simple annealing, variations of the polarization figure are due to a diminution of what we may call the birefractive power of the P. R. drop. In the case of removal of shells, variations of the figure result from diminution of

* We are indebted to Professor Baird for the use of a simple but efficient reflecting polariscope, formerly the property of Professor Henry.

thickness possibly associated with diminution of birefractive power. The solution of the drop in hydro-fluoric acid does not materially interfere with its transparency.

Our polariscopic experiments were made with the P. R. drops, Nos. 1, 2, 4, 6 and Nos. 3, 5, 7, 8, 9. The first four of these were simply annealed; the remainder examined after consecutive removals of shells. It is expedient to describe the experiments with annealed globules first. These experiments are so striking and so easily repeated on the one hand, and so difficult to reproduce accurately in a drawing on the other, that the following very careful freehand sketches of the main features of the figures are here inserted principally for purposes of record. The figures represent P. R. drop No. 6, in a fixed position between parallel nicols.



On annealing as far as $T=200°$, variations of figure are not certainly perceptible. After very long annealing at this temperature (200°), an influence appears, but is restricted to changes of color. It is particularly to be observed, that the position and contours of the original polarization figure shows an obvious relation to the position of the included bubbles (black spots in figure). This was the invariable result for all the P. R. drops examined. It is in accord with our inference of "centrifugal" contraction* discussed elsewhere. At 200° therefore, so far as these special manifestations are concerned, change of strain in glass is incipient. The P. R. drop, if broken, is still explosive; though perceptibly less so, than the original drop. After one hour of annealing in boiling mercury (360°), the changes of the polarization figure are obvious. The whole appearance is more diffuse, the colors bolder and broader and the demarcation less distinct and delicate. These striking observations can only partially be reproduced in a figure. We have encountered very marked diminution of birefractive power, after seven hours of annealing in boiling mercury, the evidences of diminished birefractive power having visibly accrued. The figure as a whole is simpler, the coloration more gross.

* L. c., p. 450.

Finally, after annealing in boiling sulphur (450°), the polarization figure has wholly vanished. We have in hand a hollow globule free from æolotropic strain. We show below that the substance of the quenched P. R. drop is under a strain of dilatation. It is necessary to bear in mind that the isotropic part of this strain is not demonstrable by optic means. The drop annealed at 450° has, however, wholly lost its explosive character.

Here therefore we encounter the first important analogy between the optical behavior of quenched glass and the electrical behavior of quenched steel. Change of strain in glass is incipient at 200°; in steel at 50°. Change of strain in glass is complete at a temperature certainly greater than 350° and less than 450°. The corresponding limit for steel cannot be so well defined.* In both cases the essential dependence of the result to be reached upon the temperature and the time of annealing (asymptotic relations) is the marked feature of the phenomenon.

Solution.—In Bulletin U. S. G. S., No. 35, we communicate a series of results on the resistance of consecutive conaxial layers of steel rods. From these we select the following digest, Table II. Having secured the rods (fine grained steel, quenched hard, length 6^{cm}, diam. $0{\cdot}6^{cm}$) in an especial clamp, the resistances between points about 5^{cm} apart were measured by a modification of Matthiessen and Hockin's method. A process of galvanic solution enabled us to remove given thicknesses of shell consecutively. After each of these removals resistance measurements were made. In the table W_t denotes the effective resistance in microhms, S_0 the corresponding specific resistance referred to the cubic centimeter; R, ϑ the mean radius and thickness, respectively, of the consecutive shells, s_0 their (calculated) specific resistance.

It is difficult to arrive at accurate values for specific resistance in these measurements; for we encounter very small values for total resistance (W_t) at the inception of the experiments, and small and irregular values of sectional area at the close. Inasmuch as sections are always measured too large, the values for specific resistance (S_0) are too large, and the error increases rapidly as we pass from greater to smaller diameters. The mean error of S_0 is certainly several per cent and hence s_0 is only an approximation. Nevertheless these results are important; they show that in case of hard rods less than $0{\cdot}6^{cm}$ thick, the values of resistance taken from circumference to axis

* "It is remarkable and significant that the electrical effects due to the annealing of a glass-hard steel rod vanish almost entirely. . . . . at a temperature at which the density of a homogeneous hot rod is the same as the density of an (otherwise) identical cold glass-hard rod.—*Bull.* 14, 97.

TABLE II.—*Resistance of consecutive cores and shells of hard steel rods.*

Rod No.	Shell or Core No.	W_t	S_0	R	ϑ	s_0
11	0	660	41·4	----	----	--
	1	820	44·1	0·31	0·024	31
	2	1000	44·0	·28	32	46
	3	1290	43·2	·24	35	45
	4	2250	43·3	·20	60	43
	5	4130	46·3	·15	37	39
	6	6620	46·6	·12	27	46
	7	16040	52·8	·09	33	42
12	0	680	41·8	----	----	--
	1	820	42·6	0·31	0·021	37
	2	1020	42·7	·28	34	43
	3	1300	44·3	·25	27	37
	4	2440	46·0	·21	54	42
	5	3390	45·7	·16	34	47
	6	5400	44·4	·13	34	47
	7	10730	57·4	·10	26	34
	8	22640	50·8	·07	29	49
13	0	660	40·4	----	----	--
	1	730	42·0	0·31	0·014	30
	2	800	42·4	·30	16	38
	3	910	43·0	·28	20	39
	4	1310	43·7	·24	44	41
	5	2110	44·0	·20	44	43
	6	3200	45·8	·16	30	41
	7	8330	47·0	·12	57	45
14	0	680	41·4	----	----	--
	1	740	42·0	0·31	0·013	36
	2	1090	54·8	----	----	--
	3	960	42·7	·29	·035	39
	4	1360	41·9	·25	42	45
	5	1990	44·7	·21	38	36
	6	2930	47·0	·17	31	40
	7	5710	42·9	·13	52	51
	8	21280	53·9	·08	44	39

along any radius do not perceptibly diminish. It was this curious result, apparently adverse to the hypothesis of strain, which induced us to examine the corresponding behavior of quenched glass.

The diameters 2ρ of P. R. drops, Nos. 3, 5, were successively reduced* as follows:

$2\rho =$ 0·79 0·75 0·72 0·69 0·62 0·56 cm.,
and $2\rho =$ 0·82 0·79 0·75 0·72 0·65 0·59 cm.

The polarization figure, drawn after each of these reductions, retained a uniform character throughout and showed no further loss of delicacy of demarcation and color than could be re-

* We desisted from further reduction of diameter because of the invasion of bubbles.

ferred to diminution of thickness. Unfortunately it is not easily possible to discriminate between the effect of diameter and the possibly concomitant effect of lessened birefractive power. Hence these experiments fail to indicate whether the removal of consecutive shells by solution is accompanied by changes of strain (shrinkage). If the fragments of a shattered P. R. drop submerged in glycerin be examined under the microscope between crossed nicols, the presence of strain in many of the individual splinters is clearly apparent. It is well to note that marked polariscopic evidence of strain remains long after the explosive properties of the drop have disappeared. We infer that the electrical behavior (resistance) of the successive cores of a hard steel cylinder is not unexemplified by the optical behavior of successive cores of a P. R. drop; though it is difficult to say whether the behavior of the partial bodies in either case (partial strains) is at all comparable with the behavior of the bodies as a whole (temper strain).

In this place it is well to advert to certain important data of Table VI. Having removed two shells (total thickness $\vartheta_1+\vartheta_2=0{\cdot}04$) from each of the P. R. drops, Nos. 10 and 11, the density of the cores were found to be 2·4166 and 2·4147, respectively. We now annealed them in sulphur (450°) and found for the densities of the annealed cores 2·4263 and 2·4261, respectively. This increment of density is quite as large as is observed when the drops are annealed as a whole.* Hence we fail to appreciate any diminution of strain due to solution. Moreover we prove below that the increment of density observed on annealing at the said temperature 450° is a true increment of the density of the *substance* of the drop; that it is not due to a partial collapse of the bubbled P. R. drop in virtue of atmospheric pressure. The observed "*after-action*," in other words is inherent in the glass itself, as we pointed out elsewhere.†

Distribution of density in P. R. drops.

Results.—Availing ourselves of the property of the P. R. drop to dissolve quietly in hydrofluoric acid, we obtained the following results (Tables III and IV) for the variation of density along transverse radii of the drops. In these tables "Diameter" denotes the mean transverse thickness of the successive cores; M, Δ_0, their mass and density (0° C), respectively. Furthermore μ, ϑ, δ, R denote the mass, thickness, density and mean radius, respectively, of the consecutive shells. If the nth core be left after the removal of n shells, then the suffixes to the number of the P. R. drop in column first give the his-

* L. c., p. 446.

† This Journal, III, xxxi, p. 452.

tory of the drops succinctly. Nearly all the measurements were made in duplicate. Δ_0 may be relied upon to within two units of the third place, δ to one unit of the second place. In no case was solution carried so far as to invade the main bubbles of the drops; they were chosen as nearly as possible free from small bubbles. The fusions were made in platinum baskets, suspended in thick clay crucibles.

TABLE III.—*Structure of P. R. Drops. Quenched.*

No.	Diameter.	M	Δ_0	μ	ϑ	δ	R
	cm	g		g	cm		
3_0	0·795	1·2576	2·4355	----	----	----	----
3_1	0·755	1·0375	2·4266	0·2202	0·020	2·478	0·387
3_2	0·725	0·8893	2·4210	0·1481	0·015	2·461	0·370
3_3	0·688	0·7650	2·4120	0·1243	0·019	2·479	0·353
5_0	0·825	1·3001	2·4400	----	----	----	----
5_1	0·786	1·0923	2·4347	0·2077	0·020	2·469	0·402
5_2	0·752	0·9317	2·4282	0·1606	0·017	2·473	0·384
5_3	0·720	0·8090	2·4181	0·1227	0·016	2·496	0·368

TABLE IV.—*Structure of P. R. Drops.*

No.	Diam.	M	Δ_0	μ	ϑ	δ	R	Remarks.
	cm	g		g	cm		cm	
7_0	0·763	1·0897	2·4386	----	----	----	----	Quenched.
7_1	0·746	1·0036	2·4346	0·0861	0·008	2·485	0·377	"
7_2	0·729	0·9254	2·4322	0·0781	0·008	2·462	0·368	"
7_3	0·712	0·8499	2·4288	0·0754	0·008	2·470	0·360	"
7_4	0·678	0·7363	2·4209	0·1136	0·017	2·482	0·347	"
7_5	0·641	0·6148	2·4098	0·1215	0·018	2·478	0·329	"
7_6	0·604	0·5136	2·3950	0·1012	0·019	2·489	0·311	"
7_7	0·539	0·3672	2·3640	0·1464	0·032	2·476	0·285	"
7_7	----	0·3102	2·495	----	----	----	----	Fused and cooled slowly.
8_0	0·790	1·1422	2·4396	----	----	----	----	Quenched.
8_1	0·775	1·0567	2·4372	0·0855	0·007	2·469	0·391	"
8_2	0·755	0·9739	2·4344	0·0828	0·010	2·471	0·382	"
8_3	0·738	0·9024	2·4317	0·0715	0·008	2·469	0·373	"
8_4	0·705	0·7741	2·4225	0·1283	0·016	2·489	0·361	"
8_5	0·667	0·6567	2·4129	0·1174	0·019	2·478	0·343	"
8_6	0·630	0·5460	2·4042	0·1107	0·018	2·457	0·324	"
8_7	0·558	0·3901	2·3743	0·1558	0·036	2·483	0·297	"
8_7	----	0·3424	2·498	----	----	----	----	Fused and cooled slowly.
9_0	0·758	1·0517	2·4390	----	----	----	----	Quenched.
9_1	0·744	0·9638	2·4370	0·0880	0·007	2·460	0·375	"
9_2	0·723	0·8689	2·4338	0·0949	0·010	2·467	0·366	"
9_3	0·707	0·7981	2·4302	0·0708	0·008	2·475	0·357	"
9_4	0·675	0·6931	2·4238	0·1049	0·016	2·474	0·345	"
9_5	0·636	0·5845	2·4161	0·1086	0·019	2·466	0·327	"
9_6	0·599	0·4866	2·4064	0·0979	0·018	2·465	0·308	"
9_7	0·536	0·3471	2·3765	0·1395	0·031	2·484	0·283	"
9_7	----	0·2779	2·501	----	----	----	----	Fused and cooled slowly.

Table V, constructed on the plan described for Tables III and IV, contains results for the variation of density along the transverse axis of drops annealed in boiling sulphur, 450°. Polariscopic examination showed these drops to be free from strain.

TABLE V.—*Structure of P. R. Drops annealed at 450°.*

No.	Diameter.	M	Δ_0	μ	ϑ	δ	R
	cm	g		g	cm		cm
1_0	0·767	1·1662	2·4398	----	----	----	----
1_1	0·710	0·8897	2·4242	0·2765	0·028	2·491	0·369
1_2	0·688	0·7859	2·4147	0·1038	0·011	2·503	0·350
2_0	0·932	1·8913	2·4420	----	----	----	----
2_1	0·874	1·4790	4·4303	0·4123	0·029	2·484	0·451
2_4	0·832	1·3118	2·4231	0·1673	0·021	2·484	0·426
6_0	0·795	1·2048	2·4468	----	----	----	----
6_1	0·740	0·9329	2·4350	0·2719	0·027	2·488	0·384
6_2	0·710	0·8436	2·4284	0·0893	0·015	2·504	0·362

In Table VI, finally, we give the results for the P. R. drops, Nos. 10 and 11. The first two shells were removed from the drops while in the original (quenched) state. Both were then annealed for two hours at 450° and a further removal of shells effected. The numbers referring to the annealed state are primed. In other respects the notation is that of the preceding tables.

TABLE VI.—*Structure of P. R. Drops.*

No.	Diam.	M	Δ_0	μ	ϑ	δ	R	Remarks.
	cm	g		g	cm		cm	
10_0	----	1·2984	2·4346	----	----	----	----	
10_1	0·761	1·0766	2·4269	0·2218	(0·02)	2·473	(0·39)	Quenched.
10_2	0·717	0·9014	2·4166	0·1732	0·022	2·481	0·370	
$10'_2$	0·716	0·9014	2·4263	----	----	----	----	
$10'_3$	0·676	0·7425	2·4136	0·1589	0·020	2·488	0·348	Annealed, 450°, 2h.
$10'_4$	0·637	0·6132	2·3982	0·1292	0·020	2·490	0·328	
11_0	----	1·0463	2·4357	----	----	----	----	
11_1	0·719	0·8555	2·4281	0·1909	(0·02)	2·471	(0·37)	Quenched.
11_2	0·680	0·7173	2·4148	0·1382	0·020	2·500	0·350	
$11'_2$	0·680	0·7173	2·4261	----	----	----	----	
$11'_3$	0·635	0·5823	2·4086	0·1348	0·023	2·505	0·329	Annealed, 450°, 2h.
$11'_4$	0·590	0·4678	2·3919	0·1148	0·023	2·479	0·306	

Discussion.—An inspection of Tables III and IV shows at once that Δ_0, the density of consecutive cores continually decreases. This is easily accounted for since the bubble error becomes relatively large as the mass, M, of the P. R. drop, decreases.

If we construct the density of consecutive shells, δ, as a function of their mean radius, R, and then compare the diagrams which obtain for the five P. R. drops (Nos. 3, 5, 7, 8, 9) we find that the loci have no salient feature in common. Hence the true variation of δ from surface to axis of a P. R. drop is here unrecognizably obscured by errors of observation. Indeed we shall find below that the probable total variation of δ attributable to strain will not far exceed 0·5 per cent. The mean accuracy of δ is certainly not much within this figure. Again if we compare the contours of corresponding curves, $\delta=f(R)$, in Table V for drops free from strain, with each other and with the contours belonging to Tables III and IV, we encounter fluctuations of the same kind in both cases. These errors include the inaccuracies of mere measurement (the mass of the drops is unfortunately small) as well as such discrepancies as result from the unavoidable invasion of small bubbles during solution.

If, however, we compare the *mean* values of δ for strained shells (Tables III, IV and VI) with the mean values of δ for shells free from strain (Tables V, VI), we find the latter values (unstrained glass) always in excess of the former. In other words, although our results are insufficiently sharp to enable us to describe the exact nature of the temper-strain in glass, they do permit us to classify it as a *strain of dilatation*, so far as we have observed, *throughout the substance of the drop*. This is an inference of importance and we have therefore drawn up the following general tabular comparison, to supplement the special and direct comparison given in Table VI.

In Table VII, Δ_s is the density of the glass itself after thorough annealing at red heat, as found in our earlier paper,*—the datum being the mean value for six drops. Δ_s' is the density of the glass after *fusion* in a platinum basket and very slow cooling. The additional increment of the density of the glass thus produced is to be noted. δ_h and δ' denote the densities of shells, strained (quenched) and unstrained (annealed at 450°), respectively. The sixth column contains the relative value of decrement of density for each drop; the second column the number of shells whose average δ is the datum given.

To facilitate further comparison we insert also the corresponding table for steel.† Here 2ρ are the diameters of the steel rods, Δ_h, Δ_s, Δ_c, their densities in the hard, the soft and the commercial (soft) states, respectively. Δ', finally, denote the densities of steel at the end of the first phase of annealing (Ca 350°) and therefore apply for rods free from strain. The table gives us the following relative decrements of density: column first, the total decrement; columns second and third

* L. c., p. 449.

† Bull. U. S. G. S., No. 27.

the decrements corresponding to the first and the second phases of annealing, respectively.

Tables VII and VIII show that both in the case of glass and of steel the mean strain effect of sudden cooling is *dilatation* throughout the substance of the quenched material;* that the

TABLE VII.—*Density relations of tempered glass relative to soft glass (mean results for shells).*

$$\Delta_s = 2{\cdot}491\ ;\ -\frac{\delta' - \Delta_s}{\Delta_s} = 0$$

P. R. Drop No.	No. of shells dissolved	δ_h	δ'	Δ'_s	$-\frac{\delta_h - \delta'}{\Delta_s}$
3	3	$2{\cdot}473 \pm 0{\cdot}006$	----	----	0·0076
5	3	$2{\cdot}479 \pm 0{\cdot}008$	----	----	0·0052
7	7	$2{\cdot}477 \pm 0{\cdot}003$	----	2·495	0·0060
8	7	$2{\cdot}474 \pm 0{\cdot}004$	----	2·498	0·0072
9	7	$2{\cdot}470 \pm 0{\cdot}003$	----	2·501	0·0088
10	2+2	$2{\cdot}477 \pm 0{\cdot}008$	$2{\cdot}489 \pm 0{\cdot}002$	----	0·0064
11†	2+2	$2{\cdot}485 \pm 0{\cdot}029$	$2{\cdot}492 \pm 0{\cdot}026$	----	0·0028
1	2	----	$2{\cdot}497 \pm 0{\cdot}006$	----	----
2	2	----	$2{\cdot}484 \pm 0{\cdot}000$	----	----
6	2	----	$2{\cdot}496 \pm 0{\cdot}008$	----	----
Mean	$(4\frac{1}{10})$	2·476	2·492	2·498	0·0063

TABLE VIII.—*Density variations of tempered steel relative to soft steel.*

No.	2ρ	$-\frac{\Delta_h - \Delta_s}{\Delta_s}$	$-\frac{\Delta_h - \Delta'}{\Delta_s}$	$-\frac{\Delta' - \Delta_s}{\Delta_s}$
I	1·90	0·0048	0·0018	0·0029
II	0·58	0·0155	0·0060	0·0095
61 to 63	0·13	0·0171	0·0068	0·0103
0	0·23	0·0133	0·0080	0·0053
21 to 29	0·08	0·0150	0·0033	0·0116
Mean	----	0·0131	0·0052	0·0079

amounts of mean dilatation for glass and for steel are of like order; that the strain in glass exceeds that of steel. We find, in general, that the practically measurable value of density is not a satisfactorily sharp datum for discerning the primary causes of the electrical, the optic and the magnetic variations

* If "quenching" means sudden cooling, then if the solid quenched be massive and thick, the inner layers cannot be quenched in virtue of their position. In the above Tables a general increase of the shell density from the surface inward is indistinctly apparent. But the evidence is not sufficient.

† In view of the large value of probable mean error of this measurement we thought seriously of rejecting it. But we were unable to find any error in the work and hence the datum has been retained. Its effect is principally apparent in the ratio, depressing it in a way adverse to our inferences.

of the substance quenched. These therefore are alone available for the nice descriptions of strain and for the interpretation of what we called elsewhere the individuality of magnets.

With the above pages we have pursued the analogy between the optical behavior of tempered glass and the electrical behavior of tempered steel into every detail of consideration which urged itself. We availed ourselves moreover of additional criteria given by the density relations of the whole or of similar parts of the bodies quenched. At every stage of our work we reached data alike in character both for steel and for glass. With these results we are justified in maintaining that sudden cooling of steel is accompanied by a strain-effect of a distinct and individual kind and of an intensity sufficient to account for the electrical properties of steel (thermo-electric and resistance constants) such as we have found them.

In one of the earlier paragraphs of the present paper we pointed out that in its divers relations to hardness steel is distinguished from glass. To further our investigation it will therefore next be necessary to inquire more specifically into the causes of hardness itself, and therewithal to endeavor to throw light on the mysterious transformations of carbon.

Washington—Prague, June, 1886.

Art. XX.—*Devonian Lamellibranchiata and Species-making;* by Henry S. Williams.

The second portion of Professor James Hall's monograph* on Devonian Lamellibranchs has been recently published, thus completing volume v, Part I, of the Palæontology of New York. The first portion was devoted to the Monomyaria. This second volume is devoted to the Dimyaria, is dated 1885, contains pages i to lxii, and 269 to 562, and plates xxxiv to xcvi with interleaved explanation of plates. The number of species described is 284, which are referred to 47 genera. Nine new genera are described; *Euthydesma* (type, *Astarte subtextile* Hall), *Sphenotus* (typical species, *Sanguinolites arcæformis* Hall, and *Cypricardia contracta* Hall), *Spathella* (type, *Spathella typica* Hall), *Glyptocardia* (type, *Venericardium retrostriatum* von Buch, *Cardium palmatum* Goldfuss, *Avicula speciosa* Hall), *Pararca*, (types, *Pararca venusta* Hall, and *Pararca erecta* Hall), *Prorhynchus* (type, *Palæanatina quadrata* Hall),

* Palæontology, vol. v, Part I, Lamellibranchiata II, text and plates. Containing descriptions and figures of the Dimyaria of the Upper Helderberg, Hamilton, Portage and Chemung groups; by James Hall, State Geologist. Albany, 1885.

Glossites (type, *Glossites lingualis* Hall), *Elymella* (type, *Elymella nuculoides* Hall), *Protomya* (type, *Protomya oblonga* Hall), one subgenus, *Palæosolen* (type, *Orthonota siliquoidea* Hall), and 79 new species. The drawing and engraving are excellent; and, next to having the type specimens, these illustrations are of great value to paleontologists, who owe thanks to the Board of Regents, who have gotten this volume finally published.

The first part of the volume, published in 1883, contains pages i to xviii, 1 to 268, and Plates I to XLVI. The complete work contains 642 pages and 96 plates, and it figures and describes 520 species and 65 genera. It is a magnificent work, placing before the student figures and descriptions of all the known species and varieties of the Devonian Lamellibranchiata of Eastern United States; it will take its place among the indispensable monographs on the table of the working paleontologist.

The illustration of these Lamellibranchs, as a whole group, was begun in 1869–70, in the issue of a pamphlet, called Preliminary Notice of the fossil Lamellibranchiata, etc., No. 2, 80 pages of which appeared, and a few copies of which were distributed in 1869. The title page of this pamphlet contained no author's name, it was accompanied by no plates. In 1884, Preliminary Notice No. 1 appeared in the 35th Report of the Regents on the State Museum.

The final text and plates of the part on Monomyaria appeared in 1883; and, finally, the part on the Dimyaria was published in 1885. In the mean time the Report of the State Geologist to the Legislature for 1882 (published in 1884, Assembly Documents 1882, vol. vii, No. 32), announced and published the diagnoses of 20 genera, all of which were new or restrictions of old genera, and, with the text were issued eleven plates of generic illustrations, in the explanation of which 54 genera and 134 species are named. Most of the plates of this double volume were completed several years before their publication, or before the text was finished. As early as 1874 sets containing a considerable number of the plates, with manuscript names, were sent out to Messrs. S. A. Miller, Dr. J. J. Bigsby, J. Barrande and Henry Nettleroth. (See plates and explanations, 1883, Preface, pp. 1 and 2.)

Mr. Miller published in his American Paleozoic Fossils, 1879, the names of these new species with reference to the forthcoming work, apparently under the advice and supervision of the author. Dr. Bigsby also published in 1878 the names attached to these plates in his Thesaurus Devonico-Carboniferus. Thus a large number of new names became quoted with references to author and plate and figure and

locality, before the text was even in the hands of the printers, reference being made to plates, but no mention of the fact that they were manuscript names.

This action aroused serious criticism, although little was made public. And, although the author doubtless expected to get the volume out very soon, it was not till 1883 that paleontologists received the plates. So much impatience was evident that the author, being unable to persuade the Legislature to publish the volume, bought a hundred sets of the plates and distributed them in 1883 to the chief institutions and workers interested in the subject in this country. With the plates were given printed explanations of plates, and the announcement was made that the text was ready and in the hands of the printer.

Much confusion and annoyance has arisen from this preliminary distribution of plates, and *publication* of names so long (at least seven years) before the regular publication of the text and plates. But, aside from this, impatience naturally becomes extreme when we look at the prodigious amount of alteration which has been made in the identification, both specific and generic, in the plates illustrating the fossils supposed to be representative types. Comparison of the plates and explanations issued in 1883 with the text and plates issued in 1885,—the plates being the same with a few additions in the latter,—reveals the following facts.

In the first set of statistics, I have compared only those species and genera both of which, in both works, were already fully described when the first work was issued in 1883. The changes made in identification of the figures, representing 284 species and 47 genera (the plates being identically the same) were 81 in number as regards the genera, and 128 as regards the species.

If now we consider the figures which were referred in 1883 to old species, and in 1885 to new species, we find 96 cases, and of figures placed in old genera in the first case and changed to new genera in 1885, we find 117 cases.

Looked at from another point of view, and eliminating from the problem all matter added in 1885 and all specific and generic names not fully described and used *before* the first publication, 1883, there were made 209 changes of identification for 205 species under consideration.

If we take the plates published in the Report of the State Geologist to the Legislature for 1882, printed in 1884, and compare the identification of the figures, which are there reproductions of those in the text and plates of 1885, a similar set of discrepancies appears.

This Report was issued, professedly, as an official illustration

of generic types or representative species of those genera, and 34 genera were illustrated; when we compare it with the final report, published only one year later, we find 19 cases of changed generic identifications, or, proportionate to the number of genera 50%, and 24 specific changes or nearly 35%.

Both these works, the plates and explanations, 1883, and the generic illustrations, 1884, were issued by the State Geologist as authoritative works illustrating the typical specimens, described mostly by him, in the State collections; specimens which had been picked out as typical for the draughtsman, and not only had they been identified by him, but they had been used in the very descriptions of genera and species for the illustration of which they were published.

In the final work, 1885, their generic and specific names are changed, in most cases with no reason given, occasionally with the note "by error" inserted in the list of synonyms. These alterations are not a simple few, but for the plates and explanations, there is an average of one alteration of identification for every species in the book. There is no disputing the facts; anyone can find them by mere comparison of the two volumes.

It seems impossible to suppose that such errors could be due to carelessness of observation; the life-time experience of the author, and his acknowledged first rank among paleontologists forbid such an explanation, and we have no reason to suppose that the identifications are not in all cases his own.

The only explanation we can conceive of is found in the system itself upon which the species are conceived and defined. Species-making and illustrating fossil forms are not the same thing. To have good figures of the most perfect typical fossil forms is of the greatest value to the student of paleontology but, if they are classified into species and genera it is all important that the differentiating characters should be discernible, at least on the typical specimens, and that too, not by experts only, but by any ordinary intelligent observer.

When we see 57 species made of a group of fossils, in which the surface is practically without differentiating characters, all the elements of form the same, showing only differences in contour, with a slight range of difference in convexity and in the angle made by the umbonal ridge with the cardinal margin, and in the points used for specific distinction with scarcely two specimens alike, we think it is asking too much of students to accept the species as of value, or to expect him to recognize them. Our hesitation is confirmed when, as in the case of the genus "*Leptodesma*," we read, as the most important distinctive character of the genus, that "the anterior end is always nasute and acute instead of auricular and rounded" (as in

"*Leiopteria*"), while in the figures we find specimens fully as "auriculate" as in several representatives of the other genus, and in the description of half a dozen species of Leptodesma we find the distinct statement that the anterior end is "round."

In another new genus, for which about a score of species are defined, the writer has seen a series of specimens, picked out of a single block of stone, expressing, by almost imperceptible gradation, almost every character exhibited by the whole range of species figured except difference of size.

The evil of this species-making habit is only aggravated by the minuteness and carefulness of the observer, and in the study of fossils it is particularly aggravated by the rarity of good specimens and the imperfection of the characters expressed. In its extreme it has ceased to be a classifying of organisms, or even fossils, and has become merely a narration of the differences exhibited by specimens.

And when a student seeks to identify new material, the more careful his scrutiny, the more surely is he driven to the idea that specimens which do not fit any of the given descriptions must be new species. So long as the Cuvierian school prevailed, there was some excuse for the practice, but in this age when the belief in the fixity of specific characters and limits is shown by theory and observation to be erroneous, there is no reason for neglecting the element of variability as a factor in the classification and definition of organisms, whether living or fossil.

The practice of differentiating species (and genera) by characters which are not clearly discernible on every fair set of the representatives of the species, or by characters which in point of variability among individuals from the same locality exceed the extent of modification separating two species of the same genus, is scarcely defensible, and leads to more confusion and uncertainty than if merely numbered photographs were distributed as illustrative of the fossils of each period and locality. If such rules were thoroughly heeded by working paleontologists the crop of new species would dwindle, but the species which were entitled to live would be capable of distinct definition and recognition.

Species and genera can scarcely be called good, so long as the author himself is unable to distribute the typical specimens, twice alike, without reference to the original labels.

In regard to the genera a word may be said: the author has retained the genus *Microdon* Conrad, although it is pre-occupied by Agassiz for a genus of fishes, and the genus *Cypricardella* Hall is acknowledged to be identical, as was shown by Mr. Whitfield (Bull. Am. Mus. Nat. Hist., vol. i, No. 3, p. 63). The first name is used with the second placed parenthetically

after it. This only complicates the matter, and the 10th of the British Association rules forbids the retention of *Microdon*.

The genus *Cytherodon* Hall, was first figured in 1872 (23d Reg. Rept., Pl. 14, figs 19, 20 and 21), with the name but with no description. The figures, 19 and 20, were *Cytherodon tumidus* Hall and *Nuculites appressus* Conrad, and 21 was specifically unnamed. In Plate VIII of generic illustrations, 1882 (publ. 1884), figs. 19 and 21 are reproduced, and both are given as illustration of the genus *Schizodus*, and the specific name *nasutus* is given to the original specimen, figured from a cast in fig. 21. In the final volume the specimens, figured as 19 and 20, are referred to *Schizodus*, and only the single specimen, represented by fig. 21, is left to represent the genus *Cytherodon*. Thus it appears that the specimen which ultimately becomes the type and sole representative of the genus *Cytherodon* Hall, was named and described and referred to the genus *Schizodus*, after *Cytherodon* was proposed as a genus distinct from *Schizodus*.

Conocardium Bronn, has no relation to the Cardiadiæ, a fact heretofore unknown and brought to light by Dr. Lindström and communicated by letter to Prof. Hall. (See note, p. xxxiv). The forms hitherto generally referred to *Cardiola* are identified with Barrande's genus *Panenka*.

The genus *Glyptocardia* is proposed for the forms called *Venericardium retrostriatum* von Buch, *Cardium palmatum* Goldfuss, *Avicula speciosa* and *Cardiola speciosa* Hall.

Modiella is said to be "in all respects very similar to some recent forms of *Modiola*." Why then propose a new genus?

The genus *Sanguinolites* M'Coy, is discarded for all the species formerly referred to that genus, and only used for two species which formerly were called *Edmondia*. The species originally called *Sanguinolites* are distributed among two new genera, *Sphenotus* and *Spathella*, and the old genus *Orthonota* Conrad.

A glance at the distribution of the *Lamellibranchs* and their range geologically, discovers the following facts. The species of the Marcellus, Genesee and Portage groups are mainly found to belong to the same genera, and these genera are rarely found in the Upper Helderberg, Hamilton or Chemung; and *vice versa*, the prevailing genera of the Hamilton and Chemung faunas are rarely found in the Marcellus, Genesee or Portage. A study of the Chemung species shows that the species common in the more western exposures are rare in eastern New York. Of the Dimyaria, the genera beginning in the Hamilton reappear more frequently and abundantly in the Ithaca group and among eastern representatives of Upper Devonian, and in the western sections they do not appear till near the close of the Chemung, or till the Waverly. The characteristic forms associated with the general Chemung fauna in western New York

are the Monomyaria, which are less abundant in the eastern sections. The Ithaca group of Lamellibranchs are more closely allied with the Hamilton than with the Chemung forms.

The species and even the genera of Lamellibranchs, as here represented, appear to be much more sensitive to conditions of environment than are the Brachiopods, as shown by the association of certain species and genera with particular kinds of deposit. The fauna of the coarser sands toward the termination of the Chemung period presents a clearly defined set of Lamellibranchs,—as the *Palæanatinas*, the "*Ptychopterias*," certain of the *Grammysias* and *Sanguinolites*="*Sphenotus*."

In his remarks upon the classification of the rocks of the Devonian, Professor Hall appears rather to add to the confusion than alleviate it. The Oneonta reds and grays, although lithologically indistinguishable from genuine Catskill rocks, and containing unmistakable *Bothriolepis* scales (a genus hitherto regarded as characteristic of the Catskill deposits), is distinguished from it, "and forms no part of the Catskill group" (p. 518).

It is stated (p. xix) that "it has not been shown that" [the Ithaca] "formation is distinctly separated from the typical Chemung lying above," and, I suppose, it is for this reason that on page 538 we find the note that "The Chemung group is here intended to include all the strata between the Catskill and Portage groups. In this volume the strata at Ithaca have been referred to the lower portion of the Chemung group." The facts are that the fossiliferous zone at Ithaca is separated from the lowest beds containing characteristic Chemung fossils by about six hundred feet of nearly barren, flaggy and shaly deposits, but with a few fossils which belong to the characteristic Portage fauna. Also the Oneonta rocks, going westward, gradually merge into the rocks which at Ithaca contain the fossiliferous beds, but on page 517 it is said "this portion of the series apparently merges into succeeding Portage groups of which further west it forms a part."

There is here some confusion. Although it would be difficult to distribute in a continuous column the several distinct local representatives of the upper Devonian for New York and Pennsylvania, it is unfortunate to throw together species of two zones so distinct as those at Ithaca and the typical Chemung zones higher up. The Ithaca fauna and its equivalents are wanting in the more characteristic of the Chemung species, and its whole facies links it as intimately with the Hamilton as with the typical Chemung fauna.

Ithaca, N. Y., April 27, 1886.

ART. XXI.—*Notes on the Composition of Certain "Pliocene Sandstones" from Montana and Idaho;* by GEORGE P. MERRILL.

A YEAR or more ago, while attempting to classify and arrange the rocks of the collections made in Montana and Idaho in 1871 by Dr. A. C. Peale of the Hayden Survey, my attention was called to a series of fragmental rocks from Little Sage Creek, Beaver Head Cañon, Devil's Pathway, Marsh Creek Valley and Port Neuf Cañon, which were labeled as "Pliocene" sandstones. A single glance showed me that these could not be ordinary sandstones, but that they bore a striking resemblance to compacted volcanic dust and sand. A glance at a portion of the dust rubbed from the specimen with the thumb and finger and placed under the microscope was sufficient to confirm my first conclusions, and to show that the stones consisted very largely of minute flakes of pumiceous glass sufficiently compacted to be readily broken out into hand specimens, but yet so friable that in most cases they could be easily disintegrated by the thumb and fingers. On mentioning the fact to Dr. Peale, this gentleman expressed great interest in the matter, and requested that I make a further examination and put my results upon record for purpose of future reference. This I have accordingly done below.

Little Sage Creek, Montana.—Three varieties of the sandstone were found from this locality, one (35890*a*)* a fine-grained, light gray and rather friable rock, quite homogeneous, and with a sharp gritty feel, agreeing closely in appearance with a pumiceous clastic rock from Citadel Cliff, East Fork of Holmes Creek, collected by the 40th parallel survey. Portions of the dust rubbed off and placed under the microscope showed it to consist wholly of a very light smoky brown, completely amorphous, glass, with the sharp angles and peculiar curved sides so characteristic of pumiceous glasses when in a finely divided state (fig. 1).† Between crossed nicols there is seen rarely a polariz-

1.

* The numbers given refer to the catalogue number of the specimen in the Museum collection.

† Other figures showing the appearance of volcanic dust as seen under the microscope are given in the following papers: On Volcanic Ashes and Cosmic Dust, Nature, April 17th, 1884; Volcanic Sand which fell at Unalashka, October 20th, 1883, Science, May 30th, 1884; and on Volcanic Dust from Southeastern Nebraska, Proc. Nat. Mus., vol. viii, 1885, p. 99.

ing fragment, and there are also present a few particles of earthy matter.

A second variety (35890*b*) is coarser, has a marly appearance, and effervesces slightly under dilute acid, showing the presence of calcite. The microscope shows but few particles of pure glass, but very many that resemble the pulverized amorphous groundmass of modern lavas. There are also a few crystalline particles too small for accurate determination, but which are probably feldspar, and other greenish dichroic ones apparently hornblendic.

A third variety (35890*c*) from this same locality is of slightly coarser texture than either of the last, of a light gray color and distinctly laminated. It contains a very considerable proportion of crystalline calcite which evidently serves as a cement. Fragments of the stone after treatment with dilute hydrochloric acid to remove the calcite are found to consist largely of colorless pumice dust, a few cleavage fragments of feldspar, folia of deep greenish brown mica, and a few earthy and ferruginous particles.

Still a fourth variety (35890*d*) is yet coarser and much firmer in texture, of a light buff color, and appears much like an ordinary fine-grained siliceous sandstone. Under the microscope the individual particles are found to be both quartzose and feldspathic (judging only from appearances, no measurements being possible), with comparatively few flakes of pumice dust. All are much eroded, and have evidently been subjected to attrition by moving waters more than any of the others from this locality.

Beaver Head Cañon.—We have but a single specimen from this locality and this (35891) like the last mentioned, except slightly coarser and with minute flakes of black mica. Under the microscope a few polarizing particles are seen but they are too small for accurate determination. The glass particles are small but stout, and lack the sharp angles noted in the other varieties. They are considerably water-worn.

Devil's Pathway.—But two samples were received from this locality. The first of these (35893*a*) is fine-grained, and light ash color like the finer varieties from Little Sage Creek and Marsh Creek Valley. Like them too it is composed entirely of pumice glass, but of a peculiar appearance such as I have never before seen, nor do I remember to have seen it described. Each fragment, however small, appears, under a power of 105 diameters, to bear upon its surface several or many minute disc-like bodies, colorless and nearly circular in outline. Under a power of 420 diameters these are seen not to be in all cases perfectly circular in outline, but several often coalesce forming continuous chains of irregular form, such as are nicely shown

in the accompanying figures (fig. 2) from Mr. Ridgeway's drawing. I can think of nothing with which they compare in appearance more nearly than that of lunar landscapes, as illustrated in works on popular astronomy.

The second variety from this locality (35893*b*) is a fine-grained, compact, dark brownish gray rock, bearing little resemblance to the others described. It is not at all friable but effervesces readily with acid. Fragments after treatment with acid till they no longer give off bubbles fall readily to a powder, which the microscope shows to consist almost wholly of quite large pumice fragments, sometimes colorless but often stained a bright yellow by ferruginous matter. A few crystalline particles are present but so stained as to be unrecognizable. The glass in this sample shows no trace of the peculiar disc-like bodies noted on the last.

2.

Marsh Creek Valley, Idaho.—Of the four samples from this locality the first two (35889*a*) like 35890*a* from Little Sage Creek, are nearly pure pumice dust, but the particles have suffered more from attrition, and are so filled with minute cavities as to have a dirty appearance under the microscope. The rock is ash-gray and has a sharp gritty feel.

The second (35889*b*) is much firmer in texture, laminated, slightly coarser and contains black particles. Its composition is, however, practically the same with the addition of a little calcite which serves as a cement. The rock effervesces readily under dilute acid, and the residue is all glass with no crystalline particles whatever.

The fourth specimen (35889*c*), although coarser and of a brownish color, is also largely pumice dust, but the particles are quite dirty-appearing under a low power, an appearance which a power of 420 diameters shows to be due to their rough, almost granular surfaces. There is but little calcite present.

Port Neuf Cañon.—The two specimens (35892) from this locality compare closely macroscopically with the finer varieties from Little Sage Creek and Marsh Creek Valley. Like them too they are composed wholly of minute fragments of pumice (fig. 3).

These last, like some of the others mentioned, contain evidently two kinds of pumice dust. The one occurs in colorless shreds with curved outlines, which rarely contain tubes or steam

cavities even in the larger forms. The other, however small the fragments may be, is always pumiceous through the presence of innumerable bubbles and tube-like cavities; a slight difference in viscosity of the original magmas having evidently caused one to become coarsely vesicular, which on breaking up through the sudden explosion of the included steam gives rise to fragments each one of which represents a portion of the partition between the cavities or vesicles, while the other, through being more finely pumiceous, gives fragments each one of which, however small, still shows its true pumiceous character. These facts are not indicative of any difference in chemical composition, but as one or the other of the forms is usually found to prevail in samples from various localities the matter seems worthy of note.

All of the above mentioned dusts yielded water when heated in a closed tube, and fused readily, with swelling, before the blowpipe. Samples submitted to Mr. J. E. Whitfield of the Geological Survey for analysis yielded results as follows:

	(35889*a*)	(35890*a*)	(35893*a*)
Ignition	6·00	6·50	5·60
Water*	1·60	1·12	3·46
$Fe_2O_3+Al_2O_3$	16·22	18·24†	17·18
SiO_2	68·92	65·56	65·76
CaO	1·32	2·58	2·30
MgO	trace.	0·72	trace.
Na_2O	1·56	2·08	2·22
K_2O	4·00	3·94	3·14
	99·92	100·74	99·66

Accepting the apparently well founded conclusions of others‡ to the effect that such dusts represent the extreme degrees of acidity of the lavas of which they formed a part, we are led to consider these as of andesitic or possibly trachytic derivation.

Samples, subsequently submitted by Dr. Peale from above Pass and Bridger Creeks near Bozeman, have also been examined.

The first of these (38448), marked as "Dry Creek Pliocene," is a fine-grained friable aggregate of a light yellowish gray color. Tested with acid it was found to contain a little lime, but consists chiefly of glass particles very pumiceous and stained by iron oxides.

* Water given off at 105° C.

† Mostly FeO. Mr. Whitfield appends the following note: These analyses not checked by duplicates, there being but a small amount of material, therefore the iron is put down as *ferric* when most of it is *ferrous*. The ignition, therefore, is not as high as it should be by reason of the oxidation of the FeO to Fe_2O_3, but is partly balanced by enter.ng the iron as Fe_2O_3.

‡ See Science, May 30, 1884.

A second variety (38447) from the south side of Bridger Creek, on summit of hill near Bozeman, is like the last but somewhat coarser, and contains also a few colorless polarizing fragments and particles of hornblende. A variety (38450) from the "upper beds," south side of the creek, is of a brown-gray color like that of Dry Creek. It is composed almost wholly of very pumiceous glass like fig. 3. Still a fourth sample (38449), from a bed just below the last is gray in color and much coarser, the fragments being in some cases 0·74^{mm} in greatest diameter. It contains also a few polarizing grains.

3.

Small particles of pumice glass were also found in connection with sundry fossil bones from the Niobrara, Loup Fork and Sweetwater regions. These bones had been quite thoroughly cleansed and handled over many times so that very little of the material in which they had originally been imbedded remained. Nevertheless by carefully picking between the teeth, in cavities and protected places, sufficient material was obtained for microscopic examination which resulted as noted.

While working upon the above, several other instances of the occurrence of this dust came to my notice which perhaps may be of sufficient interest to mention here. One of them sent by a friend in Phœnix, Arizona, is of a white and gray color sufficiently compacted to be cut in blocks of considerable size, and is stated to have been used to some extent for building purposes. It is stated to occur in "blankets" from three to fifteen feet thick, more or less tilted, and cropping out near the base of the Mazatzol Mountains at the edge of Verde River valley. The microscope shows this to be composed of pumice fragments of about 0·25^{mm} greatest diameter, and apparently identical with that described by myself from Southwestern Nebraska* (see fig. 3*b*), and quite similar to that from east of the Black Hills, Dakota, described by Dr. Wadsworth in Science of July 24, 1885, a sample of which he has been kind enough to send me.

About this same time Mr. R. T. Hill, of the Geological Survey, brought me a sample of similar dust which he had collected from near Wray Station (B. & L. R. R.) in Eastern Colorado, on the south side of the Republican River (38430), and a few days later others were brought in by Dr. Peale

* Proc. Nat. Mus., vol. viii, p. 99.

which had been received from Norton (38439) and Phillips (38446) Counties, Kansas. All were pure glass in particles never over 0·3^{mm} in greatest diameter and usually much smaller. They agree closely with those just mentioned, and also with that lately mentioned by Mr. Todd* as occurring in Eastern Nebraska.

In studying the probable origin or sources of these various beds, the distances which the dust can be carried by atmospheric currents is likely to prove of importance. It may therefore not be out of place to state here, that among a collection of pumices, ashes, etc., from the Krakatoa eruption in 1883, and which were donated to the Museum by T. H. Houghton, was a small sample of the dust (36974) that "showered on board ship Beaconsfield at the rate of one inch per hour for three days, in latitude 14° S., longitude 92° E., or at a distance of 855 miles from the scene" of volcanic activity. This dust is a very pure, nearly colorless, gray and highly pumiceous glass, the particles of which vary in size all the way up to 0·25^{mm}.

As a matter of economic interest I may say in conclusion that in Kansas and Nebraska these dusts are collected and sold in paper packages as "diamond polishing powder," or put into soap which is sold for general scouring as well as for dental use under the name of "Geyserite" soap.

National Museum, Washington, April 30th, 1886.

ART. XXII.—*Contributions to Mineralogy* by WM. EARL HIDDEN; *with Crystallographic Notes* by A. DES CLOIZEAUX.

1. *North Carolina Mineral Localities.*†

SPODUMENE.—Many transparent crystals of this species were discovered last summer on the land now known as the Morton tract. This new locality, for spodumene, is situated in Sharpe's Township, Alexander Co., and is distant one-third of a mile nearly west from the original discovery shaft of the Emerald and Hiddenite Mining Company. This locality has already furnished some very highly modified crystals of quartz, tourmaline and beryl,‡ and also some inferior crystals of spodumene. The writer was led to believe that the *gem variety* of the spodumene might be found there by the similarity of the quartz crystals found on the surface to those from the gem-bearing pockets on the neighboring land. These quartz crystals have the planes + and − 3R predominating, or they enclose silky fibers of a mineral related to amphibole. In the excava-

* Science, April 23d, 1886. † Continued from vol. xxiv, Nov., 1882.
‡ This Journal, Nov., 1882; Geol. N. C., 1881, p. 92.

tion last summer, in the search for spodumene gems, on this Morton tract, the quartz crystals above described frequently occured in the top soil; the miners here call them "hiddenite-quartz."

In a period of three months' work, nine well defined pockets of yellowish and emerald-green spodumene (hiddenite) were discovered, but the aggregate yield was comparatively small. Very few perfect crystals were found suitable for gems, but some were successfully cut. It is thought that the material may improve when the hard rock is reached; at a depth of 20 feet the loose sandy disintegrated rock remains unchanged. With the spodumene were found a few beryls of some merit as to transparency and color; great numbers of quartz crystals, some of remarkable form; a few brilliant and highly modified crystals of black tourmaline (see below); some monazite and many small crystals of ruby-red rutile mostly associated upon or within quartz crystals. Among the spodumene crystals were a few that were doubly-terminated and of a new type of form for the region, the prismatic planes being only slightly developed. These crystals were nearly colorless, quite large and semi-opaque.

The following communication from Professor Des Cloizeaux (dated Paris, Feb. 4, 1886) gives the values of the indices of refraction of this species, and shows that its refractive power is only slightly higher than that of tourmaline:

"Physically the hiddenite is identical with the yellow triphane (spodumene) of Brazil. Thanks to the new refractometer just announced by Emile Bertrand, in the Bulletin de la Société Minéralogique, it is now possible to obtain the three indices of refraction from uncut or cut sections. A first approximation gave for hiddenite $\alpha=1{\cdot}677$; $\beta=1{\cdot}669$; $\gamma=1{\cdot}651$ for yellow rays. I afterwards found $\beta j.=1{\cdot}669$ for the triphane of Brazil, cut on the prism."

Black Tourmaline.—The tourmalines, incidentally alluded to in the preceding note on spodumene, occur implanted in cavities similar to the other crystals of this region. They are noteworthy from the brilliancy and number of the planes presented. With a hand goniometer I identified the following: *O*, *I*, *i*-2, *R*, 1, $\frac{1}{4}$, $\frac{1}{2}$, $\frac{3}{5}$, $\frac{5}{4}$, 2, 3 and $\frac{1}{2}^3$—twelve planes in all. Several others were noticed but their angles could not be determined with the means at hand. One crystal presented only the planes $\frac{3}{5}R$, $\frac{1}{2}R$ and *O* all equally developed, $\frac{3}{5}R$ being new. None of the crystals were over one inch in diameter and two inches long. On many of them, minute ruby-red quadratic crystals of rutile were implanted, having the basal plane. Through thin edges these tourmalines had a deep brown color, and the smaller crystals were translucent. $\frac{3}{5}R$ measured on *O*

gave 149° as the approximate angle. R on R adj.=103°. Occurring with them were some few quartz crystals of remarkable form. Three of the most perfect presented only an upper trapezohedron ($-\frac{1}{4}\frac{5}{5}\cdot\frac{1}{4}\frac{5}{5}$?) in the termination, the unit rhombohedron not appearing even in traces. Others were hemimorphic, having several acute rhombohedrons (2, 3, 6 and $10R$?) at one extremity, and only R at the other.

XENOTIME.—Some few beautiful crystals of this rare species were discovered in the early part of last year at a locality situated about three miles east of the Emerald and Hiddenite Mine, in Alexander Co., N. C. These were found among quartz crystals, considerable rutile in the form of fine yellow needles matted together and some remarkable crystals of monazite (see p. 207). Only about one dozen crystals were found and these were discovered by washing carefully the whole of the pocket material. The color of the crystals is hair-brown, and some of them are perfectly transparent. Specific gravity =4·45—4·52. Cleavage prismatic, easy. Habit long prismatic, and in this particular differing from other American xenotimes.

My own measurements with a Fuess reflective goniometer gave as a mean of many determinations of the angle $1 \wedge I$ 131° 14′; the measurements varied from 131° 9′—131° 19′. Upon these crystals I identified with a hand goniometer the planes: I, 3, 1, 3-3 and O in traces. Of these the plane 3 is new to the species, while 3-3 has been observed by Brezina, and later by Hessenberg, Klein and Brögger. The habit of the North Carolina crystal is very closely similar to that of a Swiss crystal figured by Klein;* they are well represented by figs. 251, 252 of zircon in Dana's System of Mineralogy.

A few of the crystals were sent to Professor Des Cloizeaux, and of them he says:

"Notwithstanding the beautiful appearance of these crystals of xenotime, they present no faces sharp enough to furnish precise measurement of angles; which is to be regretted, as all angles published until now are alike uncertain. They oscillate between those of Dana and those of Brögger taken on crystals from Norway (Geol. För. Förh., Stockholm, Dec., 1883). The following are my angles:

b^1 $b^{\frac{1}{3}}$=(1 ∧ 3)=152° 25′—35′; b^1 m=(1 ∧ I)=131° 15′—45′; $b^{\frac{1}{3}}$ m=(3 ∧ I) =159° 10′—30′; $b^{\frac{1}{3}}$ a_2=(3 ∧ 3-3)=155° approx.; $b^{\frac{1}{3}}$ $b^{\frac{1}{3}}$ over a_2=(3 ∧ 3 over 3-3) =97° approx.; b^1 b^1=(1 ∧ 1 adj.) 124° approx.

Brögger gives $1 \wedge I$=131° 31′, 1 ∧ 1 adj. 124° 6′. Dana's angles $O \wedge 1$=138° 45′, $1 \wedge I$=131° 15′."

The smallest crystal measures 3^{mm} square and 5^{mm} long, while the largest was nearly 20^{mm} long and 10^{mm} thick. One trans-

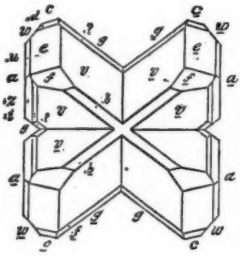
* Jahrb. Min., 1879, 536.

parent crystal having a prism of 4mm square, was 17mm long and had the zirconoid 3-3 and 3 largely developed. An analysis by Mr. J. B. Mackintosh showed the presence of 34·05 per cent of phosphoric acid combined with a base considered to be yttria but not tested.

In the auriferous gravels of middle western North Carolina, northwestern Georgia and eastern Alabama, the writer has frequently found xenotime along with monazite, etc. Some of the localities are in Hall Co., Ga., Burke, Polk and McDowell Counties, N. C. I have been most successful in the drift from the Pilot Mt. in the lower edge of Burke Co., N. C., where I found some of the xenotimes symmetrically compounded with zircon (vol. xxi, p. 244, 1881).

TWIN CRYSTALS OF MONAZITE.—In the preceding note on xenotime the occurrence of these beautiful monazite crystals is briefly mentioned. With the single exception of the crystals from this region which formed the basis of Dr. Edward S. Dana's paper,* probably no finer examples of this rare mineral have ever been found. For the most part the crystals are transparent, of a beautiful essonite-red color and are highly polished. They vary in size from four to twenty millimeters in length and thickness. They were prismatic from an unusual extension of +1 and +1-$\bar{\imath}$. The occurring planes, as shown in the figures, are:

1.



a=$\bar{\imath}$-i (100), w=−1-i (101), c=O (001), g=+1-i ($\bar{1}$01), d=½-$\bar{\imath}$ (012), e=1-$\bar{\imath}$ (011)
f=2-$\bar{\imath}$ (021), b=$\bar{\imath}$-$\bar{\imath}$ (010), v=+1 ($\bar{1}$11), z=+3-3 ($\bar{3}$11), i=+2-2 ($\bar{2}$11), u=−1 (111)

In addition there were i-2, −2-$\bar{2}$, I and several other planes which were only slightly developed, and an undetermined orthodiagonal pyramid. Of the above, v, a, g, z and e were the most frequent and predominating planes, while the prism I was only rarely shown. The twinning plane is a ($\bar{\imath}$-i, 100), the orthopinacoid, which law of twinning was first noticed by vom Rath on crystals from Switzerland. Cruciform crystals were found of almost ideal symmetry, while a few of the crystals were twinned only on one side.

A distinct but imperfect cleavage parallel to i-$\bar{\imath}$ (010), the clinopinacoid, was observed on several crystals, while the common basal cleavage was entirely absent. Efforts to produce it artificially were entirely unsuccessful.

It is to be noted that turnerite is described as having a perfect cleavage parallel to i $\bar{\imath}$, and one less distinct parallel to the basal

* This Journal, vol. xxiv, pp. 247–250.

plane. The fact that common monazite is described as having highly perfect basal cleavage suggests that the difference may be due to the thorium silicate often present as an impurity as shown by Penfield. It seems probable that these crystals, like the Swiss turnerite, consist of the pure phosphate of the cerium metals.

The density of monazite seems to offer a test for the presence of thorium, since that from Amelia C. H., Va., with a specific gravity of 5·30, contained 14·23 per cent ThO_2; that from Portland, Conn., specific gravity 5·20–·25, contained 8·25 per cent, and that from Burke Co., N. C., specific gravity 5·10, contained 5·49 per cent (analyses by Penfield). The best crystals of these now described have specific gravity ranging from 5·05–·09. No analysis of these crystals has yet been made, though some excellent material has been sent to Mr. Penfield for this purpose. Only about twenty good crystals were found altogether and the present indications are that the pocket is exhausted.

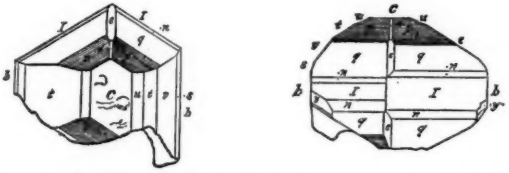
Quartz Crystals with Basal Plane.—Since 1879 the writer has been much interested in the so-called "basal-plane quartz crystals" from North Carolina; his experience goes to prove the fact that genuine basal planes are very rare occurrences on this species. In the great majority of cases the planes observed have been produced by compression or juxtaposition, and when carefully measured do not meet the requirements.

From among many crystals, appearing, when superficially observed, to possess this rare plane, I have selected two only, which, upon examination, proved to have a natural and normal development of the basal pinacoid (*O*). Not feeling perfectly satisfied with my determination—it being made with a hand goniometer—I sent the crystal showing the smoothest developed basal truncation to Prof. Des Cloizeaux for examination, and I add here a translation of a portion of a letter from him, dated May 8th, giving his results, for which I wish also to express my thanks. The crystals referred to were found last summer in Sharpe's township, Alexander Co., N. C.:

"Your crystal definitely disposes of the question of the basal plane on quartz, which, until now, has remained doubtful. My measurements prove that the base is quite perpendicular to the vertical axis, which we may question of many of the so-called 'basal planes' on quartz. $p(+R)\wedge a^1(O)=128°$, calc. 128° 13′. This adjustment gave an elongated reflection of which the center gave 128°. $p(+R)\wedge p$, right = 94° 12′, calc. 94° 15′. The face $b^{\frac{3}{2}}(-\frac{1}{5}R3)$ is also present on this crystal. I have identified this face before on crystals from Wallis, and on amethysts from Brazil and Hungary." $p(+R)\wedge b^{\frac{3}{2}}(-\frac{1}{5}R3)=147°\ 40'$, calc. 147° 39′.

2. *A remarkable crystal of Herderite.*

The crystal here noticed was found in the early part of 1884 at the locality near Stoneham, Me., by Mr. N. H. Perry, but it did not come before me for examination until after the notices of this mineral had appeared. (This Journal, xxvii, pp. 73, 135, 229.) Excepting 3-2 (362, *x*), i-$\frac{3}{2}$ (120, *l*) and i-3 (100, *n*) all the planes observed on the American crystals occur on this crystal, and one new plane, the unit macrodome, is seen to be present, 1-$\breve{i}$ (101, *d*). The pyramid 1 (111, *p*) is invariably dull and waxy looking on the crystals from Stoneham and for this reason it is distinguished from the other planes. This



crystal has a diameter through the macro-axis of 25^{mm} and in point of size and general perfection is unequaled.

The figures represent this crystal natural size and with the natural development of the planes. Fig. 1 shows it with the brachy-axis placed vertical, while in fig. 2 the position is the normal one. The occurring planes are thirteen in number with several others slightly indicated, they are: *O* (001, *c*); i-$\breve{i}$ (010, *b*); *I* (110); 1-$\breve{i}$ (101, *d*); $\frac{3}{2}$-$\breve{i}$ (302, *e*); 1-$\breve{i}$ (011, *u*); $\frac{3}{2}$-$\breve{i}$ (032, *t*); 3-$\breve{i}$ (031, *v*); 6-$\breve{i}$ (061, *s*); 1 (111, *p*); $\frac{3}{2}$ (332, *q*); 3 (331, *n*) and 3-3 (131, *y*). This American herderite can be readily distinguished by its phosphoresence in the dark when gently heated. It exhibits under this treatment a bright orange-yellow color; amblygonite from the same locality showed a bright lavender-blue phosphoresence.

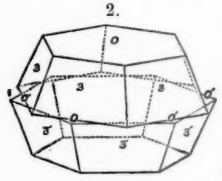
The index of refraction for this species has been determined anew by Des Cloizeaux, with results differing from those first announced. He now gives as the mean index of refraction for yellow rays: β=1·609; this was obtained from a small prism with an artificial face parallel to the base and a second formed by the plane *e* (302). Mr. Perry has lately found this mineral at the tourmaline locality near Auburn, Me., and a few excellent crystals were obtained there. These were announced in the Trans. N. Y. Acad. Sci. for Dec. 7, 1885, by Mr. G. F. Kunz.

In conclusion I wish to thank Mr. C. S. Bement, to whose cabinet this crystal belongs, for the opportunity of describing it.

3. *Twin crystal of Molybdenite.*

The crystal here figured was brought to my attention by Mr. C. S. Bement, who was the first to identify its twinned structure. It was found near Renfrew, Canada, along with other remarkable crystals, some of which weighed nearly a pound. One measured $3\frac{3}{4} \times 2\frac{7}{8} \times 2$ inches in thickness, while another, a thick hexagonal prism, was 4 inches long. My own measurements on this crystal and on several others from the same locality (made with hand goniometer) give the angle of the pyramid on the base as 108°, but this value at best is only approximate. These crystals and the method of twinning here figured seem to prove that molybdenite should be referred to the hexagonal system. Some few of the crystals suggest that the species may possibly be hemimorphic like greenockite, but this cannot be positively determined at present with the material at hand.

2.



4. *On the Phenacite from Florissant, El Paso County, Colorado.*

Since the original announcement of this locality,* by the writer, many additional crystals have been found by Mr. Hiestand and the best of them were sent by me to Professor Des Cloizeaux, at Paris, who has very kindly examined them. I here give substantially his results as communicated to me in a letter dated Feb. 4, 1886.

"I send a drawing of the two most remarkable of your crystals. One is a projection parallel to the base, offering an opportunity to study the new face z and the proportional development of the other occurring faces (fig. 1). The other is a perspective view of a very small but highly modified (abnormally) crystal, placed so as to show its most interesting forms" (fig. 2). The planes found by Des Cloizeaux on these interesting crystals are here given in his symbols, Miller's and Dana's, i. e.—

e^2 ($2\bar{1}\bar{1}$, i); d^1 ($01\bar{1}$, i-2); k ($3\bar{1}\bar{2}$, i-$\frac{5}{4}$=$b^{\frac{1}{3}}$ d' $d^{\frac{1}{3}}$); p (100, R); b^1 (011, $-\frac{1}{2}$); $e^{\frac{1}{2}}$ (122, -1); e^1 ($\bar{1}11$, -2); d^2 ($02\bar{1}$, -1^3): z ($32\bar{1}$, $\frac{1}{2}^2$=$d^{\frac{1}{2}}$ $d^{\frac{1}{2}}$ b') new; w ($21\bar{1}$, $\frac{1}{2}^3$, =$d^{\frac{1}{2}}$ d' b'); b^2 (021, $\frac{2}{3}$-2); y ($31\bar{1}$, $\frac{4}{3}$-2, =$d^{\frac{1}{3}}$ d' b').

Des Cloizeaux's calculated and observed angles (the latter in parentheses) on these Colorado crystals are as follows:

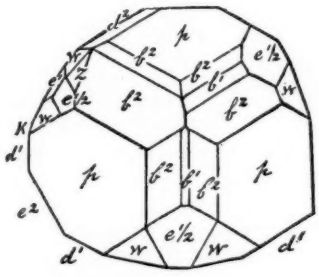
d^1 w adj.=134° 15′ (133° 50′ approx.); d^1 z over w=123° 0′; d^1 b' over w=107° 59′; w z adj.=168° 45′ (168° 50′); b^1 b' over O=144° 2′ (144°); e^2 d^2 adj.=147° 51′ (148 approx.); e^2 w over d^2 122° 30′ (123°); e^2 $e^{\frac{1}{2}}$=107° 40′; e^2

* Vol. xxix, March, 1885, p. 249.

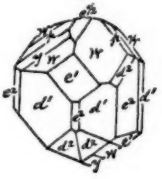
p over $e^{\frac{1}{2}}$=72° 20′ (72°); d^2 w=155° (154° 39′); w $e^{\frac{1}{2}}$ adj.=165° 10′ (165° 10′); w z over $e^{\frac{1}{2}}$=156° 32′ (156° 30′); $e^{\frac{1}{2}}$ z adj.=171° 23′ (171° 25′); $e^{\frac{1}{2}}$ p adj.=144° 41′ (144° 40′); z p adj.=153° 18′ (153° 10′); d^3 y adj.=162° 44′; d^3 z over y=150° 44′; y z adj.=168° 0′; z p opposite=138° 36′ (138° 25′).

"Colorado phenacites on amazonite (microcline) offer exactly the same association as those from the Urals. It will be noticed by reference to both the figures that, the face $w=(\frac{1}{2}^3)$ is here shown holohedral, whereas, ordinarily hemihedral. The face $b^2=(\frac{2}{3}^2)$

1.



2.



presented an anomaly on one crystal in its having the appearance of being hemihedral. This crystal also had the edge replaced between d^2 and $p=(\mathrm{R3}/\!\!\diagdown\mathrm{R})$ which would have the symbol $d^{\frac{1}{5}3}$ $\mathrm{R}\frac{9}{4}$, or possibly $d^{\frac{8}{3}}$ $\mathrm{R}\frac{11}{5}$. This crystal gave the following angles, i. e.—

d^2 w=153° approx.; d^2 $e^{\frac{1}{2}}$=139° 30′; w $e^{\frac{1}{2}}$=165° 30′; d^2 $d^{\frac{13}{5}}$=172° 30′, calc. 172° 36′—173°; d^2 p=150° 30′; $d^{\frac{13}{5}}p$=157° 30′, calc. 157° 27′; b^2 b^2 (hemihedral)=139° 15′."

It seems now that specimens from this locality were first shown to Mr. Whitman Cross by the finder, Mr. Hiestand, but no public announcement of their identification was made by him until after the publication of my note on the occurrence. (This Journal, March, 1885.) Among the last discoveries at this locality were some exceptional crystals, implanted on quartz crystals, that were fully 1^{cm} in diameter. One quartz crystal had within it a small phenacite crystal, having bright faces.

ART. XXIII.—*Turquois from New Mexico;* by F. W. CLARKE and J. S. DILLER.

AT Los Cerillos, New Mexico, about twenty-two miles southwest of Santa Fé, are mines of turquois which have been worked for centuries. The locality has been repeatedly

described,* from archæological and geological points of view; but, as far as we are able to ascertain, the turquois itself has never been fully analyzed, nor has it been subjected to complete microscopic study. Having at our disposal a very full suite of specimens, collected during the summer of 1885 by J. W. Powell, Director of the U. S. Geological Survey, we have thought it desirable to investigate the subject more thoroughly, and to present our results in such form as to render them readily comparable with the published data concerning turquois from other localities.

The turquois occurs imbedded in its matrix, sometimes in nodules, oftener in seams or veins. It varies in color very widely; ranging from a pure sky-blue, through many shades of bluish green and apple-green, to dark greens which show no blue whatever. The dark green nodules often shade off to nearly white at the center, sometimes resembling in structure, as Blake has observed, certain varieties of malachite. Many of the specimens are seamed or streaked by limonite, which has been derived from accompanying pyrite; and the latter mineral occasionally is found, bright and unaltered, enclosed completely in masses of clear blue turquois.

For analysis, three samples of turquois were selected, representing as nearly as possible, the most definite types of the mineral. They may be summarily described, as follows:

A. Bright blue, faintly translucent in thin splinters.

B. Pale blue, with a slight greenish cast, opaque and earthy in luster, and of sp. gr. 2·805. Blake gives the density from 2·426 to 2·651 for the green variety.

C. Dark green, opaque.

	A.	B.	C.
H_2O	19·80	19·60	18·49
Al_2O_3	39·53	36·88	37·88
Fe_2O_3		2·40	4·07
P_2O_5	31·96	32·86	28·63
CuO	6·30	7·51	6·56
SiO_2	1·15	·16	4·20
CaO	·13	·38	undet.
	98·87	99·79	99·83

Analysis "A" is not quite complete, for enough material could not be obtained without the destruction of too valuable specimens. The silica in it was due to traces of admixed rock from which the material could not well be perfectly freed. "C," however, was free from rock; and the silica in it must be

* W. P. Blake, this Journal, II, xxv, 227, 1858. J. S. Newberry, "Report of the Exploring Expedition from Santa Fé to the Colorado," etc., 1859; printed, 1876. B. Silliman, this Jonrnal, III, xxii, 67, 1881.

accounted for otherwise. Silliman reports the turquois as containing 3·81 of copper, which corresponds to 4·78 of CuO; but he gives no other quantitative data.

In attempting to discuss these results it will be well to compare them with two other published analyses of turquois from different localities. First, we have the figures given by Church* for the well-known variety from Persia; and secondly, the analysis by G. E. Moore† of turquois, pseudomorphous after apatite, from Taylor's Ranch, Fresno County, California.

	Persia.	California.
H_2O	19·34	19·98
Al_2O_3	40·19	35·98
Fe_2O_3		2·99
FeO	2·21	
P_2O_5	32·86	33·21
CuO	5·27	7·80
MnO	·36	
	100·23	99·96
Sp. gr.	2·75	2·798, 2·815

These analyses, leaving temporarily out of account that of the dark-green variety, agree well with each other in their atomic ratios. Dividing the percentages by the proper molecular weights, and treating the bases together, the following ratios appear.

	Total base.	P_2O_5	H_2O
New Mexico, A,	·468	·225	1·100
New Mexico, B,	·479	·231	1·089
Persia,	·492	·231	1·075
California,	·470	·234	1·110

In each case the base stands to the acid in a ratio very slightly in excess of two to one; and that excess may fairly be accounted for upon the supposition that it represents a trifling admixture of limonite. The water is present in a proportion a little under that of five molecules to one of phosphoric acid, the variation here being due to the differences in the percentages of copper. If we calculate the amount of phosphoric acid necessary to satisfy the alumina, and then reckon the phosphate so obtained as requiring five molecules of water, we shall have left over a quantity of copper, acid, and water corresponding to a very simple formula; and the turquois will appear as a variable mixture of the two following salts:

$$2Al_2O_3 . P_2O_5 . 5H_2O.$$
$$2CuO . P_2O_5 . 4H_2O.$$

* Chem. News, x, 290. Dana's Mineralogy. p. 581.

† V. von Zepharovich and G. E. Moore. Zeitsch. für Kryst. u. Min., x, 240.

In the Californian turquois the analytical results fit these formulæ quite sharply, and give the ratio between the two compounds as approximately four to one. The first formula may be regarded as that of normal turquois, and may be written in rational form, halved, as

$$Al_2HPO_4(OH)_4.$$

The copper salt, to which the mineral owes its color, is to be considered merely as an impurity; a view which is emphasized by the analysis of the dark-green turquois, "C." In the latter case the same ratios apply, modified by the presence of silica, which is nearly sufficient to form with the copper a normal metasilicate, similar to if not identical with chrysocolla. This silicate, with whatever blue tinge of color it might have, affected by the yellow or brown of the iron present, probably gives the turquois its green hue. It is exceedingly probable that the purity of tint in gem turquois is due to the copper salt alone; and that degradations of the color towards green are ascribable to admixture of salts of iron. It is noteworthy that, of the three turquoises analyzed, the bluest contains the lowest percentage of copper. This could hardly be the case were not the colors of the other samples modified by some impurities; and compounds of iron would naturally produce an effect in the observed direction.

Sections of the three varieties of turquois were studied under the microscope, and found to be of essentially the same character. Although deeply colored in the hand specimens, the thin sections appeared almost clear and transparent. Between crossed nicols the deep blue and green forms were seen to be composed of minute grains, or short, thick fibers; but in the paler varieties the fibrous structure was more pronounced. The optical properties of both grains and fibers are the same throughout. They are all weakly doubly refracting, but have a rather high refractive index. The finely granular portions have a pale bluish aggregate polarization, less intense than that of chlorite; but when the mineral is distinctly fibrous it polarizes like some forms of serpentine, with light colors of the first order. The fibers are generally somewhat bent and interwoven, but lie approximately in the same direction. Each fiber becomes dark when parallel to the principal section of either of the crossed nicols, indicating that they must crystallize according to either the quadratic, hexagonal, or rhombic system, instead of in one of the inclined systems as was the case with the fibers studied by Bücking* in the turquois of Fresno County, California.

A section was prepared of a distinct vein of pale-green tur-

* See paper by v. Zepharovich and Moore, previously cited.

quois, which showed that the fibrous structure is directly across the vein perpendicularly to its walls. Small fissures, running into or across the veins, have the fibers of turquois arranged perpendicularly along their sides just as serpentine arranges itself along fissures in olivine. Sometimes the fissures are minute and curved; but the resulting arrangement does not simulate the radial fibrous or spherulitic structure described by Bücking* as found in the turquois of California, Nevada and elsewhere.

The perpendicular arrangement of the turquois fibers along fissures crossing the vein, indicates that the mineral may have been derived from the alteration of another substance with which the vein was formerly filled. We would suppose, of course, that the original vein material was itself a phosphate; and the only one after which turquois is known to be pseudomorphous is apatite; a species which not infrequently occurs in veins. The opinion that the turquois has resulted from such an alteration is favored by the presence of other alteration products, to be noted in considering the composition of the country rock in which the turquois is found. It is also suggested by Hermann's analysis of blue oriental turquois, in which the equivalent of 3·41 per cent of calcium phosphate was actually determined.†

The rock in which the veins of turquois occur is described by Blake as "a granular porphyry, yellowish, gray, or white in color, porous and earthy in texture. It decomposes rapidly by weathering, and very much resembles a sandstone." In the collection made by Major Powell there are several good examples of the rock penetrated by the turquois. It is a fine-grained, reddish, feldspathic rock, mostly fresher than that described by Blake, and it has a microgranitic aspect. It contains numerous particles of biotite and pyrite, with stainings of oxide of iron. The hand specimens look as though they had been crushed, and the fissures thus formed so filled as to produce irregular veins and nodules. The veins are small, and mostly composed of turquois, in which are imbedded a few scales of biotite, particles of pyrite, and considerable quartz and oxide of iron. Scales of biotite are found abundantly in the iron-stained cavities, as well as in the solid portions of the rock. Some specimens of rock, containing much pale blue turquois of earthy texture, have been completely kaolinized, and a partial analysis of the kaolin gave the following results:

* Zeitsch. für Kryst. und Min., ii, p. 163.

† See Dana's System of Mineralogy, p. 581.

H_2O	12·88
SiO_2	52·38
$Al_2O_3 + Fe_2O_3$	33·49
P_2O_5	none
MgO	1·17
CaO	trace
	99·92

Although the mineral itself was white, the alumina from it was distinctly reddish with the iron.

Under the microscope the rock is seen to be composed chiefly of feldspar, with a considerable amount of biotite, epidote, pyrite and limonite, and some amorphous substance. It is somewhat microgranitic in structure, and the irregular, interlocking grains of feldspar vary in size from ·01 to ·8^{mm} in diameter. Most of them are considerably kaolinized, so as to appear cloudy in ordinary light; but between crossed nicols the original outlines of the grains become more distinct. Their optical properties indicate that the feldspar is orthoclase; an opinion which is fully borne out by the subjoined analysis of the rock, which shows a remarkably large proportion of potash.

H_2O	3·28
SiO_2	56·68
Al_2O_3	16·62
Fe_2O_3	6·50
P_2O_5	·73
MgO	·79
CaO	·59
CuO	trace, undet.
MnO	1·02
FeS_2	2·21
K_2O	11·18
Na_2O	1·03
	100·63

The porphyritic crystals are generally Carlsbad twins with irregular outlines. There are occasionally small grains of fresh, transparent plagioclase, which has evidently resulted from alteration.

The biotite of the rock occurs in noteworthy quantities, but is very unequally distributed. It is frequently aggregated in groups of scales, and may be seen most abundantly in small cavities. It sometimes occurs intimately associated with the turquois, but unlike the latter it is one of the primary minerals. The small quantity of quartz present is a secondary product, so intimately associated with turquois as to suggest

their genetic connection. Pyrite is scattered rather uniformly throughout the rock in small cubical crystals easily seen in the hand specimen. They are sometimes altered to limonite, but in other cases they have been completely replaced by pseudomorphs of epidote. The specimen of rock which was subjected to analysis probably contained an amount of pyrite rather greater than the average.

One of the most important constituents of the rock, because of its very close association with the turquois, occurs in the form of bright yellow grains. They are not distinctly pleochroic, but have a high refractive index, with strong double refraction, and give brilliant aggregate polarization. The particles are usually very small, and grouped together in irregular compound grains so as to suggest nothing of crystallographic form. In several cases, however, elongated simple grains show inclined extinction; which indicates that the mineral must be either monoclinic or triclinic in crystallization. Judging not only from the properties enumerated, but also from the percentage of lime in the rock, this mineral is in all probability epidote. It is evidently connected genetically with the turquois, for it is almost uniformly found upon the border of the latter, and is most abundant in its neighborhood.

Concerning the origin of the turquois-bearing rock, it may be stated that Professors Newberry and Silliman, both of whom studied it in the field, regard it as eruptive, and probably of Tertiary age. The occurrence of this veritable orthoclase rock in the West is of special interest from the facts disclosed by recent investigations that in many of the rocks previously described as trachytes the predominating feldspar is plagioclase.

The very small size of the veins and their limited distribution show that the turquois is of local origin, and emphasizes the idea that it has resulted from the alteration of some other mineral. In addition to the evidence already cited to show that the turquois has been derived from apatite, we have the fact that epidote, a lime-bearing mineral, is present as a secondary product. The oxidation of pyrite may have had something to do with initiating the process of alteration, and the alumina of the turquois was probably derived from decomposing feldspar. The latter suggestion was made by Silliman, who also examined microscopic sections of the rock, and reported apatite as present. No apatite, however, could be seen in the specimens examined by us. A search for it at the locality would certainly seem to be desirable.

U. S. Geological Survey, Washington, April, 1886.

ART. XXV.—*On the Electrical Resistance of Soft Carbon under Pressure;* by T. C. MENDENHALL.

A PAPER by the writer on "the influence of time on the change in the resistance of the carbon disk of Edison's Tasimeter," was published in this Journal in July, 1882. The object of the paper, as its title indicated, was to present the results of some experiments with the carbon disk which appeared to show that, when pressure was applied, the entire diminution of resistance did not take place at once, but that the reduction continued with diminished rapidity through a considerable period of time. At the conclusion of the paper brief reference was made to investigations of the same subject by Mr. Herbert Tomlinson and by Professors Sylvanus P. Thompson and W. F. Barrett.

Only the conclusion reached by some of these physicists was at that time known to the writer, their verdict being that the observed diminution of resistance was really due to the better surface contact of the electrodes and not to any actual change in the specific resistance of the carbon itself.

The last paragraph in the paper contains the following: "without knowing anything about the nature of these experiments the writer desires to record his belief that this theory does not entirely account for the facts stated above."

This, certainly not too rash, declaration of belief in a true pressure effect was the subject of decidedly unfavorable criticism in the columns of one or two European scientific journals; and in this Journal of December, 1882, Professor Sylvanus P. Thompson published an article entitled "Note on the alleged change in the resistance of carbon due to change of pressure," which was an exceptionally severe criticism of the previous paper by the writer. In this article Professor Thompson refers to the investigations of Mr. Tomlinson, Professor Barrett and himself and also to experiments made by Professors Naccari and Pagliani and Mr. Conrad W. Cooke, and he declares that, with the exception of Professor Mendenhall, all who have investigated the point are agreed in their verdict "that this alleged effect was due not to any change in the specific resistance of carbon, but to better external contact between the piece or pieces of carbon and the conductors in contact with them." The truth of this statement is the question at issue. It may be well to remark, however, that although Professor Thompson makes this assertion in December, Mr. Tomlinson had shown, nearly a year earlier, in a paper presented to the Royal Society, on the 26th of the previous January, that the

electrical resistance of hard carbon was diminished by pressure. The amount of the diminution is small, however, and he afterwards expresses the opinion that in such instruments as the microphone transmitter, the greater portion of the observed diminution in resistance is due to variation in surface contact.* Mr. Tomlinson's experiments were made with hard carbon, similar in character to that made use of in experiments to be described presently.

In the summer of 1884, the writer communicated, to the American Association for the Advancement of Science, a brief account of experiments which satisfied him that the opinion which he had previously expressed concerning the nature of the phenomenon was unquestionably correct. Within the past year the subject has been taken up again, and by means of improved methods and instruments, all doubts seem to have been removed.

Innumerable experiments made by physicists of many countries have established, beyond question, the fact that the electrical properties of matter are modified by stress and strain. In carbon the effect of pressure is to diminish resistance. For hard carbon this was established by the investigation of Mr. Tomlinson. In compressed lampblack, as seen in Edison's disks, the effect is very great and that this is for the most part a true pressure-effect is proved, it is believed, by the experiments about to be described.

In the beginning it was desirable to determine, roughly, the magnitude of this effect in the case of hard carbon. For this purpose a copper plated rod, such as is used in the arc lamp, about 12^{cm} in length and $1{\cdot}5^{cm}$ in diameter, was selected and its ends were ground flat at right angles to its axis. The plating was then removed, except that a band about $\cdot5^{cm}$ in width was left near each end of the rod. Two cork rings $1{\cdot}5^{cm}$ thick were fitted to the rod, after which they were tunneled out on the inside, and a hole was made in each so that when they were in place over the copper bands, and mercury was poured in, it would flow around the ring tunnel and make a contact with the carbon as satisfactory as could be desired. The ends of the rod were protected by thin plates of vulcanite, and it was placed between the jaws of a vise. The current from a battery of two or three gravity cells was passed through the rod by plunging wires into the mercury cups formed by the corks. By this arrangement it was possible to apply pressure at the ends of the rod without in any way influencing the contacts through which the current passed.

The terminals of a reflecting galvanometer whose resistance was about 5000 ohms were also introduced into these mercury

* Nature, March 16, 1882.

cups and enough additional resistance was introduced to make a convenient deflection of the spot of light upon the scale. When all was adjusted and the spot of light was at rest, the pressure was applied by turning the handle of the vise. In every instance the deflection decreased showing diminished resistance. This effect was not due to the heat produced by compression as experiment proved that cause to be inadequate. It was found to be necessary to make the carbon rod decidedly warm to the touch in order to lower the resistance by the same amount, besides the effect was not transient as would have been the case if it had been due to the change in temperature. It was also found that compression at right angles to the direction of the current produced a similar effect, but less in magnitude. These facts had been already announced by Mr. Tomlinson.

These experiments with hard carbon or with other rigid bodies are comparatively easy, as there is no difficulty in applying the pressure independent of the contact surfaces, so that possible variation of the latter need not be considered. Unfortunately it appears to be quite impossible to secure this arrangement in the examination of soft carbon. It cannot readily be obtained in forms different from the small disk or button in which it originally appeared, and it is so fragile that it requires the most careful manipulation. Under these circumstances the only thing to do is to secure the best possible surface contact of the poles to begin with. Perhaps the ideal arrangement would be a disk with its two opposite faces electro-plated with copper, through which a contact with mercury can be secured. The electro-plating of two opposite faces of a disk of compressed lamp-black is a work of extreme difficulty and so far as known to the writer has not yet been accomplished, although he is greatly indebted to Mr. Edison for a serious and persistent effort to secure this result, none the less appreciated because, owing to the extremely fragile character of the disk, it proved to be unsuccessful.

It was therefore necessary to depend upon the contact of mercury with the surface of the carbon itself. As this was the contact employed by Professor Barrett in the experiment which Professor Thompson considered "crucial," its use can hardly be objected to in this instance.

The arrangements for the test of the soft carbon were as follows: two glass tubes about 20^{cm} in length were bent at one end into a quarter of a circumference, so that when the two were joined and the straight branches of the tube were in a vertical position the appearance was that of the letter "U," the height being about 15^{cm}. Near the lower end of each a short tube was sealed in, over which rubber tubing could be passed, and at the lower part of the curve, in each, a platinum

wire was passed through and sealed. The ends of the tubes were ground flat, and they were mounted in such a way that while one was fixed in position, the other could be moved toward or away from it in one plane, and so that the ground ends of the curved parts were always exactly opposite to each other. The movable tube was then taken from its place, the ground edge of its curved end was coated with glue, and it was carefully brought down upon the upper surface of a carbon disk which rested in a horizontal plane. The glue causing the disk to adhere to the tube, the latter could then be secured to its sliding stand, ready to move into place. The ground edge of the fixed tube was now coated with glue, after which the movable tube holding the carbon disk was gently moved up until the disk pressed against the end of the other tube, the glue forming the junction. In this way a carbon wall or partition was formed between the two halves of a "U" tube. When the glue had hardened, mercury was introduced on both sides to a height sufficient to entirely cover the faces of the carbon disk. The current was introduced through the platinum electrodes which plunged into mercury cups on either side.

In some of the earlier experiments variations of pressure were produced by the addition of mercury to the two branches of the tube, but vastly better than this was the method latterly used in which the pressure of air was substituted for that of mercury. Glass plates were sealed on the open ends of the two upright branches thus inclosing a space on each side, except at the small side tubes to which short pieces of rubber tubing were attached. These were joined by means of a "T" tube so that equality of pressure on both faces of the disk was secured.

The circuit consisted of the battery, the disk and an additional resistance varying from 3 ohms to 10 ohms for purposes of comparison. The electric ends of the disk and of the resistance were joined to a specially arranged key, by means of which either could be connected with the terminals of a reflecting galvanometer whose resistance was about 7000 ohms. By means of the deflections of the needle of this galvanometer, the resistances were compared and variations noted, the arrangement being substantially the same as that previously used in the experiments with hard carbon. A pressure gauge, sometimes of water, sometimes of mercury, was attached to the apparatus to indicate variations in pressure, and these variations were generally produced by blowing from the mouth into a rubber tube about two meters in length. Very many experiments were made, all without exception, showing great diminution in the resistance of the disk by increase of pressure, and it will be sufficient to quote a few of the results.

The disk is sufficiently sensitive to show very slight changes in atmospheric pressure. On closing the open end of the rubber tube, and slightly pressing any part of it between the thumb and finger, the spot of light instantly moved, showing decrease of resistance. A pressure measured by 5^{mm} of water produced a decided effect. The resistance of the disk, with its mercury and platinum wire connections, under ordinary conditions was slightly greater than 6 ohms. A pressure measured by 5^{cm} of mercury instantly reduced it to less than 3 ohms. If the pressure was maintained, a slow fall of resistance continued for a long time, as found in the previous investigation of the subject. If the initial pressure was small, the recovery would be instantaneous on its removal, but if it was large, so as to greatly reduce the resistance, it was found that the recovery would not be complete on the withdrawal of the pressure, sometimes falling short as much as ten per cent, after which a slow rise would take place. This result is not quite in agreement with the statement made in the first paper upon this subject, which was based, however, upon a much less satisfactory series of experiments.

An examination was made of the effect of the strength of the current upon the resistance of the disk. The weakest current used was a little less than ·001 ampere, and the strongest was about ·37 ampere, so that one was approximately 400 times the other. Throughout this range no sensible differences in the resistance of the disk were observed, the agreement at the two extremes being within the errors of measurement. Under all conditions the effect of variations of pressure was the same.

The faces of a soft carbon disk are always smooth and polished; the surface of hard carbon on the contrary is generally more or less rough and irregular. It would appear, therefore, that, if the reduction of the resistance of soft carbon by increase of pressure is due to better surface contact, this reduction of resistance should be much more marked with hard than with soft carbon. Experiments already described showed that the effect of pressure on hard carbon was very small; so small, in fact, that the pressure of a few centimeters of mercury would hardly produce a sensible effect.

The substitution of a disk of hard carbon for the soft, in the apparatus described, ought to show then whether any considerable part of the resistance variations observed could be attributed to variation of contact between mercury and carbon. A disk of hard carbon similar in dimensions to the soft disk previously employed was accordingly inserted between two similarly arranged tubes. The result of this experiment was to show, as had been anticipated, a small decrease of resistance when the pressure was increased. A pressure of about 7^{cm} of

mercury reduced the galvanometer deflection from 36 to 35 divisions of the scale. This indicates a change of less than three per cent, resulting from a pressure which with the soft disk lowered the resistance by more than sixty per cent. There can be little doubt that this small reduction is due almost entirely to better surface contact produced by pressure.

Throughout all of the experiments with soft carbon, it exhibited more or less irregularity in its behavior. The application of a pressure very largely in excess of the maximum referred to above would sometimes result in a permanent reduction of the resistance of the disk, indicating that a permanent set had taken place. By the exercise of care, however, what may be called the "normal" resistance may be maintained fairly constant for a considerable length of time.

Conclusions.—When carbon is prepared in the form of compressed lamp-black, its electrical resistance varies greatly with the pressure to which it is subjected. A small part of this variation is doubtless to be attributed to change in surface contact between the carbon and the electrodes through which the current is introduced, but by far the larger part (provided any effort is made to secure good surface contact) is due to a real change in the resistance of the carbon itself. The resistance of carbon in this condition is fluctuating and uncertain to a degree that seems to prevent its use as a factor in any device for the accurate measure of pressure.

Art. XXVI.—*Comparison of Maps of the Ultra Violet Spectrum;* by Edward C. Pickering.

One of the first accurate maps of the ultra-violet portion of the solar spectrum was made in 1873 by the late Dr. Henry Draper. A photograph of a normal diffraction spectrum was prepared and copies printed by the Albertype process. A wide distribution was given to this work, which was published also in this Journal, cvi, p. 401. This map extended from 345 to 394, adopting as a unit the millionth of a millimeter. The scale was such that one unit equaled $0{\cdot}31^{cm}$. Soon after, M. Cornu published in the Annales Scientifiques de l'Ecole Normale Supérieure, III, 421, a steel engraving representing the region extending from 343·5 to 412·5. The map was intended as a continuation of the work of Ångström and was on the same scale, one unit equaling 1^{cm}.

The recent publication of a photograph of the solar spectrum by Professor Rowland furnishes a convenient standard with

which these maps may be compared. The improved apparatus and enlarged scale of Professor Rowland's work rendered it probable that its accidental errors would be unimportant in the present comparison, especially as the measures are only to be carried to hundredths of a unit. As a check upon its systematic errors a comparison has been made with the investigations of Dr. Müller and Dr. Kempf in the Publicationen des Astrophysikalischen Observatoriums zu Potsdam, V. Three hundred lines were measured between the limits of 686 and 389. About two hundred of these are contained in the region covered by Professor Rowland's map. A comparison of a number of them indicate that the accidental errors are very small. The width of the bands or groups of lines into which many of the lines are resolved renders it largely a matter of judgment where the center should be taken. The systematic differences are about 0·01, or more strictly the wave-lengths according to Rowland exceed those of Müller and Kempf by about one eighty thousandth part. The region 588 to 590 occurs on four of the strips of Rowland's map. The positions of forty-five of the lines contained in this region were estimated on all four strips and indicated corrections of +·0007, +·0007, −·0009 and −·0004 respectively. These quantities are probably due to accident. They are inappreciable by the method of measurement employed, as they would not exceed one five hundredth of an inch on the map.

The specimen of Dr. Draper's map with which the comparison was made was not a proof impression, but was taken from a copy of this Journal. The positions of seventy-six lines were read, estimating the divisions to tenths by the aid of a reading glass having a focal length of about 10^{cm}. Preference was given to well defined lines, a few bands with hazy edges being omitted. The corresponding positions of these lines were then read from Professor Rowland's map, estimating the tenths by the unaided eye. The differences were arranged in groups as shown in table I, according to their wave-length. Each group extends over one unit, the middle points having the values given in the first column of the table. The number of lines contained in the group is given in the second column, and the mean of the residuals, Draper *minus* Rowland, in the third column. The fourth column gives the results of a similar comparison with the map of Cornu. The same lines were used except that having a wave-length of 393·76, which is not given on Cornu's map. Some uncertainty exists regarding three or four of the other lines, where the engraving does not agree with the photograph. No large residuals are thus introduced, since lines in the right place are selected even if the intensity is incorrectly represented.

TABLE I.

λ	No.	D—R.	C—R.
372·0	3	+·037	—·087
373·0	5	+·032	—·070
374·0	3	+·037	—·077
375·0	3	+·023	—·070
376·0	3	+·003	—·060
377·0	2	+·005	—·075
378·0	3	+·007	—·093
379·0	3	—·003	—·097
380·0	3	—·007	—·023
381·0	1	+·020	—·070
382·0	3	—·017	—·073
383·0	5	—·030	—·084
384·0	2	—·030	—·090
385·0	6	—·027	—·102
386·0	5	—·026	—·086
387 0	3	—·027	—·133
388·0	2	—·045	—·150
389·0	3	—·067	—·153
390·0	6	—·062	—·128
391·0	5	—·042	—·084
392·0	3	—·057	—·107
393·0	2	—·080	—·100
394·0	2	—·075	—·100

The results of table I are combined in table II, where each group extends over five units. An inspection of these tables

TABLE II.

λ	No.	D—R.	C—R.
375·0	16	+·023	—·070
380·0	13	—·003	—·079
385·0	21	—·028	—·097
390·0	19	—·055	—·119

shows that the maps differ systematically, the wave-lengths according to the map of Dr. Draper being too great for the lines of short wave-lengths. The relation is very closely represented by the formula,

$$D - R = \cdot0052\ (379\cdot6 - D),$$

in which D and R represent the wave-lengths according to Dr. Draper and Professor Rowland respectively.

Representing by C the wave-lengths according to Cornu, we have in like manner the correction,

$$C - R = \cdot003\ (351\cdot7 - C).$$

Where the wave-lengths are only carried to hundredths of a unit the corrections may be more readily applied by means of table III, which gives the limits within which each correction of one hundredth of a unit is to be applied. The first part of the table gives the corrections of Dr. Draper's map, the second the corrections of M. Cornu's map.

TABLE III.

Limits.	Corr. Dr.	Limits.	Corr. Dr.	Limits.	Corr. C.
370·04 to 371·95	+·05	382·48 to 384·39	—·02	370·00 to 373·33	—·06
371·96 to 372·87	+·04	384·40 to 386·31	—·03	373·34 to 376·66	—·07
372·88 to 374·79	+·03	386·32 to 388·23	—·04	376·67 to 379·99	—·08
374·80 to 376·71	+·02	388·24 to 390·15	—·05	380·00 to 383·33	—·09
376·72 to 378·63	+·01	390·16 to 392·07	—·06	383·34 to 386·66	—·10
378·64 to 380·55	·00	392·08 to 393·99	—·07	386·67 to 389·99	—·11
380·56 to 382·47	—·01	394·00 to 395·91	—·08	390·00 to 393·33	—·12

As an example of the use of this table, if a line on Dr. Draper's map has a wave-length of 371·95, its true wave-length may be assumed to be 372·00. In like manner 390·00 becomes 389·95. The same readings on Cornu's map would become 371·89 and 389·88.

Applying these corrections to the wave-lengths derived from the map of Dr. Draper, we obtain results which agree very closely with those given by Professor Rowland. The mean difference for the seventy-six lines compared was 0·012, corresponding to about one eight-hundredth of an inch upon the Draper map. Probably a remeasurement of the larger differences would still further diminish the average value. No differences were rejected, the two largest having the values 0·05 and 0·06. The mean difference of 0·012 gives a probable error of 0·010, which includes the errors of the two readings and the accidental errors of both maps. We may therefore assume that that the probable error of a wave-length derived from the map of Dr. Draper will not exceed one one-hundredth of a unit if the correction given above is first applied. The minuteness of this quantity is a good illustration of the accuracy attainable from a record obtained automatically by photography. The wave-lengths given on the map of Cornu when corrected in the same way give an average deviation of 0·025, equal to about one one-hundredth of an inch on the map. This is in accordance with the belief of Cornu himself that the probable error of the drawing would not exceed 0·03.

ART. XXVII.—*On two hitherto undescribed Meteoric Stones;* by EDWARD S. DANA and SAMUEL L. PENFIELD.

1. *Meteorite from Utah.*

IN the summer of 1869, the meteoric stone now described was found by Mr. Clarence King in Utah, on the open prairie between Salt Lake City and Echo. It was given by Mr. King

to Professor Brush and he presented it to the Yale College Collection. Nothing is known in regard to the circumstances or time of its fall; in that dry climate it may well have lain exposed on the surface of the ground for a long time without disintegration, especially as it was well protected by its crust.

The weight of this stone is 875 grams; it is oblong in shape, about 12^{cm} long, and 9^{cm} in its greatest width; one edge is sharp and wedge-like, and one end is relatively sharp, the other rounded. The surface is comparatively smooth and shows only a few broad and shallow pittings. A uniform crust, smooth except for minute angular elevations on certain portions and not very thick, covers it almost completely. The color of the crust is reddish black, in consequence of the partial rusting of the fused material. A small portion of the mass has been broken from one end to give material for study.

The interior of the stone is of a dark bluish gray color, distinctly mottled by its chondritic character, and showing a rather large proportion of iron irregularly distributed through it, with minute patches of troilite. The small portions of the interior of the stone which had been exposed are much stained by the oxidation of the iron, but this change has penetrated comparatively little into the mass, and the stone as a whole is exceptionally hard and firm. The nature of the mineral substances which, together with the metallic parts, make up the mass can be only imperfectly made out by mere macroscopic examination; thin sections, however, under the microscope show this very satisfactorily. The olivine is the most prominent constituent. This appears frequently in spherules or "chondrules" of the size of very small shot; these are made up of a multitude of individual grains having distinct rounded outline and each with its own optical orientation. These granular chondrules are sometimes enclosed by an iron border, and as the grains of olivine are fresh and clear and give brilliant polarization colors, they form very beautiful objects under the microscope. The separate grains in these cases are closely packed together, but sometimes show a little intermediate glassy matter. The olivine also appears in relatively large fragments, much fractured, but showing by the common optical orientation that all belongs to a single individual. Still again the olivine is seen in chondrules which have a distinct coarsely fibrous structure in consequence of the inclusions of dark-colored glass.

The bronzite (enstatite) appears in irregular crystal fragments scattered through the mass. Also in chondrules with fine fibrous structure usually eccentric; these have sharp angular outlines in many cases and appear to be but fragments of the original spherules—in this as in some other respects the stone has a

marked brecciated character. To the bronzite also are to be referred occasional large spherules having a coarsely fibrous or columnar structure, the fibers lying in several directions within the limits of the same individual.

Plagioclase feldspar seems to be sparingly present in crystalline fragments, showing distinct, though not sharp, twinning structure. Especial interest attaches to this constituent of the stone because it shows most clearly the brecciated character just alluded to. One piece for example has been broken transversely a number of times and then cemented by the groundmass so that it still preserves in general its original outlines though made up of separate sections. This feldspar is rich in black inclusions lying parallel to the twinning lines. A number of patches of an isotropic mineral, which is probably to be referred to maskelynite, were also observed.

The specific gravity of this meteorite was found to be 3·66. A careful chemical analysis (Penfield), gave the following results. It was divided in the first place into the nickeliferous iron 17·16 per cent and the mineral part including the troilite and silicates 82·84 per cent.

The analysis of the iron yielded:

Fe	91·32
Ni	8·04
Co	0·60
Cu	0·04
	100·00

The mineral portion was divided into:

Soluble in HCl	Troilite Fe (Ni) S	6·70 with NiS=0·62
	Silicates	48·85
Insoluble in HCl including chromite		43·97
Water		1·14
		100·66

The analyses of the soluble and insoluble portions gave further:—

	Soluble in HCl.		Insoluble in HCl.	
SiO_2	19·70	40·33	24·11	54·83
Al_2O_3	0·25	0·51	2·12	4·82
FeO	10·42	21·33	3·80	8·64
MgO	17·17	35·15	10·80	24·56
CaO	0·81	1·66	1·47	3·34
Na_2O	0·16	0·33	0·87	1·98
K_2O	0·02	0·04	0·05	0·12
P_2O_5	0·32	0·65	----	----
Chromite	----	----	0·75	1·71
	48·85	100·00	43·97	100·00

The molecular ratio of the silica to bases in the soluble portion is 1:1·72, so that besides the olivine the glassy portion is probably here included. The composition of the insoluble part implies that it is made up largely of bronzite with a little plagioclase. Among the stones in the Yale College collection that from Chantonnay seems to bear the closest resemblance to this new stone.

2. *Meteorite from Cape Girardeau, Missouri.*

This Missouri meteorite has waited just forty years for public description. It became the property of the Yale Museum several years ago, having been purchased from Dr. Otto Lugger of Baltimore, to whom we are indebted for the facts in regard to its history. The stone was obtained by Dr. Lugger when he was residing in St. Louis, about the year 1875, from an acquaintance, by the name of Padberg, whom he had employed to collect for him various objects in natural history, minerals and so on. According to Padberg's statement, the meteorite had formed part of his mineral collection since 1847. It was provided with a label which stated that it fell at 3 o'clock on the afternoon of August 14th, 1846, accompanied by a loud report, upon a small farm belonging to an Englishman by the name of William Free. This farm lay some 7½ miles south of Cape Girardeau in southeastern Missouri. The meteorite was given to Padberg by Free in 1847. It was stated further that the meteorite broke upon its fall into three pieces, two of which form the mass here described, and the third was polished and presented by Dr. Lugger three years ago to Professor Uhlberg.

The account of the history of the stone, of which the above is an abstract, is so complete and circumstantial as to make it appear worthy of confidence, notwithstanding the many years which have passed since the stone fell.

The stone, when it became the property of the Museum here, consisted of two parts weighing together 2,058 grams. These two portions fitted closely together, and the fractured surface between them was fresh except for the oxidation of the iron. The general shape of the stone is roughly rectangular with dimensions of 12×10×10 centimeters. The surface is smooth with no sharp edges nor angular projections. On one side, the crust, which is rather thick, shows with remarkable distinctness the lines of flow diverging from what was probably the projecting point in its flight through the air; on what was presumably the rear side the crust is thicker, rather rough and somewhat cellular or slag-like. One portion of the surface is simply blackened over without having a distinct crust, as if a part had been broken off shortly before it struck the ground. The general color of the fresh surface is light gray except as it

is stained by the rusting of the iron; this oxidation has proceeded rather far, as might have been anticipated, and indeed the appearance of some portions suggests that there may have been present also some deliquescent compound (e. g. iron chloride). The mass as a whole is somewhat porous and easily fractured.

The metallic particles, which have mostly a bluish tarnish, are scattered very uniformly through the whole mass. The chondritic character is distinct though not strongly marked, yellowish white spherules of olivine, and others of a dark gray (bronzite?) are sparingly scattered through it; for the most part it appears to be granular crystalline.

In the sections examined under the microscope the olivine is seen in granular form, not often distinctly grouped in chondrules; the bronzite also in longitudinal fragments. The dark gray chondrules have an indistinct fibrous eccentric structure and act rather feebly on polarized light—they may be also bronzite. The feldspar is not particularly distinct, although occasional patches of a dull gray in polarized light probably belong here. Glassy matter was not distinctly observed.

The specific gravity of a fragment of the stone was found to be 3·67. The chemical analysis (Penfield) showed a relation of native iron to troilite and silicates very near that of the Utah meteorite, namely, 17·90 to 82·10 per cent.

The analysis of the iron gave:

Fe	91·93
Ni	7·39
Co	0·63
Cu	0·05
	100·00

The analysis of the latter portion yielded:

Soluble in HCl	Troilite	6·95
	Silicates	42·68
Insoluble in HCl, including chromite		50·19
Water		0·58
		100·40

The soluble and insoluble parts gave further:

	Soluble.		Insoluble.	
SiO_2	15·50	36·32	28·00	55·79
Al_2O_3	tr.	----	2·78	5·54
FeO	9·52	22·31	3·97	7·91
MgO	17·17	40·23	11·87	23·65
CaO	----	----	1·68	3·35
Na_2O	0·12	0·28	0·93	1·85
K_2O	0·02	0·04	0·12	0·24
P_2O_5	0·35	0·82	----	----
Chromite	----	----	0·84	1·67
	42·68	100·00	50·19	100·00

The composition of the first portion corresponds very closely to a ferruginous olivine, the ratio of silica to bases being 1 : 2·17. The insoluble part is evidently for the most part bronzite with probably a little feldspar to which the alumina and soda and most of the lime belong. This stone belongs to rather a common type of meteorites, the light gray chondrites; there is, however, no stone in the Yale College collection from which it could not be at once distinguished.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *On a Density Pipette.*—Amat has devised a modified form of pipette, by which the density of a liquid may be approximately determined. It consists of a straight glass tube, graduated, to the upper end of which is attached laterally a U tube also graduated on both legs. The standard liquid is placed in this U tube and by means of a rubber spherical cap on the upper end of the pipette, the given liquid may be drawn into the main tube. Noting the height of this column and comparing it with the difference of level in the standard columns, the specific gravity of the given liquid may be obtained in terms of the standard. A small correction must be made for capillarity at the narrowed end of the main tube. The results given agree with those made with the specific gravity bottle, to the second decimal place. The liquid in the pipette is allowed to flow out by removing a cork from a lateral opening near the top.—*Bull. Soc. Ch.*, II, xlv, 482–484, May, 1886. G. F. B.

2. *On Water of Crystallization.*—Pickering has discussed the nature of the water of crystallization in salts and the relation which this water bears to the salt with which it is associated. He concludes (1) that the theory that the sulphates contain either one or two molecules of "constitutional" water finds no confirmation whatever in general considerations as to their formation, properties, composition and analogies with other salts; (2) that the most decisive evidence as to whether a given salt is an "ortho" salt or a basic salt is afforded by the nature of the metals which form such salts, and by ascertaining whether it displaces the hydrogen atoms singly or in pairs. Those metals which displace "acid" hydrogen most energetically are the ones which exhibit least tendency to form basic salts; (3) that although the heat of hydration of a salt indicates that the lower hydrates are generally more stable than the higher ones, it gives no information whatever as to whether the various water molecules in any particular hydrate are all similarly combined or not; (4) that no information on this point is afforded by the different temperatures at which the water molecules are evolved; (5) that

experimental evidence, no less than general considerations, show that the water molecules in a lower hydrate are affected by the addition of more water. The higher hydrate does not *contain* the lower one; (6) the displacement of one of the water molecules in the magnesian sulphates by K_2SO_4 affords no grounds for the supposition that the one displaced differed in any respect from the others. The physical properties of the resulting double salt afford a strong argument in favor of the displaced molecule being water of crystallization only; (7) that the specific heats of hydrated salts throw no light on the nature of the different water molecules; (8) that experiments with the solid hydrated sulphates of the magnesian metals show that the volume of the water in the lower hydrates is relatively less than in the higher hydrates. But the difference is not such as would indicate any difference in nature of any of the various hydrates, and certainly affords no information as to the volumes of the individual water molecules in any particular hydrate; (9) that the volume of dissolved salts may show that one molecule of water in these magnesian sulphates differs from the rest; but the data available are at present too meager to warrant any definite conclusions being drawn. At any rate, whatever the difference may be, it is of exactly the opposite nature to that which would be exhibited if it were water of "constitution;" (10) that with the exception of this last-mentioned fact, which can at present be regarded as a possibility only, we have no grounds for supposing that the various water molecules in a hydrated salt are not all combined in a similar manner, and do not all occupy exactly the same position with regard to the salt-nucleus; that in short a hydrated salt is not a symmetrical substance. At the same time it must be admitted that we have no positive evidence to show that it is symmetrical, and we must regard it as such provisionally only, till some unquestionable evidence in favor of or against this view be forthcoming.—*J. Chem. Soc.*, xlix, 411–432, June, 1886.

G. F. B.

3. *On the Fulminating silver of Berthollet.*—Raschig has studied the compound obtained by Berthollet nearly a hundred years ago by the action of ammonia upon silver oxide. For the preparation of the substance, a solution of silver nitrate was precipitated with sodium hydrate, and the silver oxide washed by decantation. For each gram of silver nitrate used, there was poured upon the silver oxide 2 cubic centimeters of an ammonia solution containing 25 per cent of NH_3. The oxide of silver dissolved readily leaving only a slight turbidity. The solution thus obtained was divided into several portions, each being placed in a porcelain dish about 10^{cm} in diameter, so proportioned that no dish contained the oxide from more than one gram of nitrate. Each dish was covered with a watch glass and allowed to stand for 16 to 20 hours. The ammonia evaporated and the fulminating silver was deposited, as a black crystalline mass. After washing it was analyzed by digestion with very dilute sulphuric

acid, by which a residue of metallic silver was generally left. The dissolved silver was precipitated with hydrochloric acid, and in the filtrate the ammonia was determined as platino-chloride. The results of sixteen analyses gave ratios which were very close to three atoms of silver for one of nitrogen; leading to the formula NAg_3. Other samples of the substance prepared by warming the ammonia solution of the silver oxide on the water bath, or by precipitating it with alcohol, gave the same ratio on analysis. It exploded by the slightest concussion when dry and requires great caution in handling even when moist. It is soluble in ammonia and in potassium cyanide.—*Liebig's Ann.*, cxxxiii, 93–101, April, 1886. G. F. B.

4. *Formation of Anhydrite or anhydrous Calcium Sulphate.*—The formation of anhydrite has recently been held to require pressure—a pressure of ten atmospheres, which is that of the sea at a depth of about 350 feet. Professor G. Spezia, of Turin, publishes (in the *Atti* of the Turin Academy, vol. xxi, 1886) the following results of experiments by him. The action of aluminum sulphate on powdered apophyllite under a pressure of 300 atmospheres for three months produced *gypsum* instead of anhydrite. The same was the result from a piece of calcite kept in a solution of copper sulphate under 95 atmospheres for three months. He obtained from the reaction of magnesium sulphate with calcium nitrate diffused in water, and in another trial diffused in a saturated solution of sodium chloride, under pressures of 100 and 500 atmospheres, in both cases only gypsum. From these and other similar experiments here mentioned he concludes that some condition besides that of pressure is required to produce anhydrite. The author alludes to methods of obtaining anhydrite, citing G. Rose's results, that gypsum heated to 120°–130° C. in a saturated solution of sodium chloride changed to anhydrite, and that at a lower temperature the reverse took place.

II. Geology and Mineralogy.

1. *Volcanoes of Japan;* by John Milne (Trans. Seism. Soc., Japan, ix, Part II. Yokohama, 1886. 184 pages, 12mo, with maps and plates).—Mr. Milne gives, in this long and valuable memoir, an account of the many volcanoes of Japan and the adjoining islands, from historical documents and to some extent from personal observations, and illustrates the subject by a map showing their distribution, and by plates containing views of many of the volcanic cones. The highest of them is the noted Fuji-san (=Mount Fuji), by outsiders usually called Fujiyama, near Yokohama. The altitude, deduced from many observations, is between 12,400 and 12,450 feet. It is generally reported to be extinct; but Mr. Milne in an ascent in 1880 saw some steam issuing just outside of the pit of the crater. Of the other volcanic peaks, one (Norikurayama) is 10,447 feet high; Mitake is 10,000 feet; three are between 9,000 and 10,000; two between

8,000 and 9,000 and fifteen between 5,000 and 8,000. Mr. Milne ascended Oshima, an active volcano on the island of that name (height 2,500 feet) in May, 1877, after an eruption which commenced on the 4th of January. The interesting points are that the eruption began with only a very slight vibration or earthquake; the slope on the side ascended was 40° to 50°; explosions within were heard before reaching the top, which were afterward found, when at the top, to occur in succession every two seconds, with occasional pauses, and to be due to successive outbursts of steam, each producing a throw upward of ashes and bombs sometimes nearly to a height of 1,000 feet; the fragments fell vertically or nearly so unless wafted by the winds. The walls of the crater were vertical and about 300 feet in height. The volcano Asamayama, 8,800 feet high (p. 95), is said to break forth in eruption after it has become clogged by depositions of sulphur; but some source of action within must be the real cause of its periods of activity.

The number of volcanoes, easily recognized as such by their cones, is 129, and of this number 51 are still active; 16 of the active are in the Kuriles, 11 in Yezo, and 24 in the central and southern region. Records of 233 eruptions are reported by Mr. Milne (some dating back of the Christian era); 32 of them in the northern district, 63 in the central, and 138 in the southern. Of those whose month of outbreak is known—153 in number—80 occurred in the winter months and 73 in the summer; and the largest number in the months of February and April. The eruptions hence follow, says Mr. Milne, the same law as the earthquakes: "During the winter months the average barometric gradient is steeper than in summer; and this, with the piling of snows in winter, gives rise to long continued stresses, in consequence of which certain lines of weakness in the earth's crust are more prepared to give way during the winter months than they are in summer."

The lavas consist mostly of augite-andesite; but those of Fujisan, Oshima, and Hakone are basic and like basalts, giving for the silica 49 to 52 per cent, with nearly 10 per cent of iron oxides. The rocks are strongly magnetic, and some pieces have been noticed to be polar. Dr. E. Naumann states in a paper in a volume of the Seismological Journal of Japan, that near Ganju-san, for some unexplained reason, the magnetic declination has in the last eighty years decreased 19°, *changing in that time from* 14° 30′ *E. to* 5° *W.;* and that the change is less as you recede from the mountain. Such a fact, says Mr. Milne, makes frequent observations desirable about the large volcanoes that lie in the track of vessels.

Mr. Milne discusses the forms of volcanoes, in continuation of former observations referred to by Mr. Becker in his paper in volume xxx (1885, p. 283) of this Journal. The principle discussed by these authors has reference especially to one of the conditions on which form depends—the resistance to crushing,

occasioning "the form due to a self-supporting mass of coherent material." Other causes mentioned by Mr. Milne are the tendency in the larger particles to roll farthest down the mountain; atmospheric denudation; position of crater; direction of ejection; direction of wind during an eruption. These are all conditions pertaining to cones consisting chiefly of fragmental material and have little bearing on the larger volcanic cones or mountains consisting mostly of lavas, among which are those of Hawaii. Outflowing lavas, by cooling around the central vent, with adhesion between the successive outflows, may, as Prévost long since stated (and illustrated by means of beeswax), make slopes of all angles from 1° to 90°. The fusibility of the lavas, the degree of heat above that of fusion, the size of the outflows, the position of the fissures and outflows, all have their effects. Orthoclase lavas, owing to high fusing point, make steep cones or domes, and basaltic lavas those of gentle slope, sometimes as low as 3°. Mount Loa, one of the latter kind, the angle 3° to 8°, has a double curvature in its surface—a flattened or dome-shaped top and wide spreading nearly flat base on its south and southeast sides.* But although almost 14,000 feet high, it is not near the crushing limit of height; for, as Mr. Milne states, even sandstone could be built up, on a base of nine miles in diameter, to a height of 14,500 feet without crushing, and granite to a height of 20,000 feet. The base of Mount Loa is from forty to fifty miles in diameter, and virtually larger, because braced on the north and west by Kea and Hualalai, and the slope about the top is very small. All volcanoes over 5,000 feet in height are probably made at least one-half of solid lavas, although having, it may be, an exterior of fragmental material. The problem of form is therefore a complex one. J. D. D.

2. *Summit crater of Mt. Loa, Mokuaweoweo.*—Mr. Alexander, Surveyor General of the Sandwich Islands, has surveyed the summit crater of Mt. Loa, and we have from him a photograph of his map and an account of the survey. He makes the highest point, on the west margin of the pit, 13,675 feet above the sea-level. As mapped, also by Wilkes, it has a large central pit, with a smaller one on both its northern and southern sides, each of which communicates with the central pit. The length of the whole is 19,500 feet; the greatest breadth 9200 feet; the greatest depth 800 feet; area of central crater 2·3 square miles. It is a marvelous fact that a volcano of so great height should be so frequently in eruption—not usually over its brim, but through fissures commonly 1000 to 3000 feet below it. But, notwithstanding the depth of the pit, outflows from fissures opening to the very summit, and directly on its margin, some-

* The writer's Manual of Geology, on page 724, has a profile of the island of Hawaii, as seen from the eastward, copied from his Exploring Expedition Geological Report (p. 159), which was drawn by him with much care when *at sea* off the island; it shows, besides the outline of Loa, the contrast between it and that of Mt. Kea. In the view the position of Kilauea was not distinguishable.

times occur, and one such on the southwest side, on the highest part of the brim, is reported by Mr. Alexander as having been a very recent occurrence, and as an immense stream flowing toward Kahuku, besides sending lava cataracts into the south crater. The lava, moreover, is as solid and heavy as that of Kilauea.

With regard to the smaller craters, more than fifty in number, situated about Loa, Kea and Hualalai, the three great mountains of Hawaii, Mr. Alexander states that they have as a general thing been formed on fissures running N. 40°–60° W. though a few are on a N. 50° E. line. "The major axis of the great craters is generally at right angles" to the mean trend of the group N. 30° W.; this is at least true of Kilauea and Mokuaweoweo. "In both of them the highest walls are on the western side, and in both the action is working toward the southwest."

3. *Kilauea, Hawaii.*—The crater Kilauea has again liquid lavas in the pit called Halemaumau, in its southwestern part. On the 26th fires had appeared. On June 29 the lake was about 225 by 435 feet in its diameters, as measured by crossing it, it being crusted over from cooling, but hot for shoes. On July 4th the crusted surface stood at a level 75 feet higher than on the 29th, and two streams of lava 40 feet wide flowed from beneath the table-top of lava into the lower portion of the pit. As usual the lava became cooled in surface to a "satiny blackness" a short distance from its visible source, and this cooling retarded its flow, so that "it 'gartered' itself, as it were, in narrow, smooth folds, arranged in parallel curved lines across the surface of the flow;" but soon the stream, overcoming the partial obstruction thus made, burst through at the front and "rolled out again in slow-moving streams of a rich red color." The display of light in the crater and from the illuminated clouds at night were fine at times during the week. The above facts are cited from letters of June 26th and July 4th in the Pacific Commercial Advertiser, signed C. (F. L. Clarke). The eruption here recorded is one of the common outflows of Halemaumau in the bottom of Kilauea, and not a true eruption of Kilauea.

4. *Map of Maui, of the Hawaian Islands.*—Under Mr. W. D. Alexander, a wall map of the island Maui, $3\frac{1}{2}$ by $4\frac{1}{2}$ feet, has been made, which has recently been published. It is the result of very careful work and gives all topographical as well as political details. It has special interest to the geologist on account of the twin-volcanic character of the island, the contrast in mountain features of the two parts, the wonderful crater of Haleakala at the summit of the eastern part, the highest point of whose rim is 10,032 feet above the sea-level; and the illustrations of the progress of erosion over the two mountain regions.

5. *The Taconic stratigraphy and fossils. Note by* J. D. Dana.—The question has been asked me, in view of the great fault and overthrust in the Scottish Highlands, whether a like event may not have happened in Berkshire, and the juxtaposition of fossils and metamorphic rocks be thus explained. The ques-

tion has been answered, but not directly, in my paper of June, 1885, In view of the enquiry since made I here state the differences. In Scotland, gneissic and other crystalline rocks, through a length from north to south of 90 miles, were carried westward ten miles over scarcely crystalline fossiliferous Silurian rocks, and effects of the friction were visible in the production of metamorphic schists at the contact and in other ways. In Berkshire the facts are as follows:

While the region is one of numerous north and south overthrust folds, with the thrust westward, there is no evidence in the positions of the rocks, abrasions, or in any other way, of a general overthrust.

The rocks within the limits laid down by Emmons are, in most of its cross sections, beginning on the *west* in eastern New York, as follows: (1) Glossy hydromica schist, resembling glossy roofing slate. (2) Feebly crystalline gray to grayish white limestone. (3) Hydromica slates, slightly coarser than (1) and usually somewhat chloritic. (4) Limestone less feebly crystalline than (2). (5) Hydromica schist of the Taconic Range, somewhat coarser than (3) and commonly more chloritic, and less coarse on the western side of the belt than on the eastern, and along the latter sometimes garnetiferous. (6) Coarse crystalline limestones including white to gray marble. (7) Mica schists, often garnetiferous, graduating into and interlaminated at times with quartzyte. (8) Coarsely crystalline limestones, marbles. (9) In some parts, quartzyte which is at times interlaminated with mica schist. (10) Gneiss, mica schist, hornblendic gneiss, etc. In southern Berkshire, as a consequence of the general fact that the metamorphism is greatest to the south, No. (5) is a chloritic hydromica schist, in places somewhat garnetiferous, on the west side, and *mica schist, garnetiferous and staurolitic* on the *east* side, the two sides four to five miles apart.

The nine belts consist alternately of limestone and schist, with quartzyte at the east, 2, 4, 6, 8 being limestones. They vary in width from a fourth of a mile or less to three or four miles or more; and the whole width of the north and south Taconic formation in the section is about twenty-five miles. The dip of all the strata is *in general* eastward and conformable.

If, now, the eastern rocks had been thrust westward over the western, or the western over the eastern, it would be plainly manifest. There is not a shadow of evidence in favor of the idea.

The fossils that have been found within the Taconic system occur in the limestones (2) and (4) just west of the Taconic Range. There is no mica schist within ten miles of them, and the nearest gneiss is 20 miles off. The limestone and the associated hydromica schists are *alike* in grade of metamorphism, both being feebly crystalline.

Four limestone belts are mentioned in the cross section; but in other sections there are only two, and in others five. The

* This Journal, III, xxix, 441.

schists constitute isolated ridges in what may be called a sea of limestone, and the four limestone belts blend with one another around the ridges; even the most western blending in some places with the eastern. Thus there is oneness in the system of rocks.

The oneness in system and origin is manifested in oneness of gradation in metamorphism, as has been above indicated. The increase in the degree of metamorphic action on going *from west to east* is extremely gradual. It is just such as should follow from variation in intensity of metamorphic action—that is, variation in the degree of heat, moisture and pressure concerned.

Such facts give augmented force to the evidence that there has been no general overthrust. The only rock in the series about which there is any question as to its relative position is that of the quartzyte which occurs here and there over the eastern half and on the eastern margin of the area.

The facts as to oneness of system and metamorphism show also that the fossils have a profound bearing on the whole Taconic system, although found only in the feebly crystalline rocks on the west.

Fossils are not to be looked for in coarse mica schist or gneiss, or in coarsely crystalline limestone. The more or less heated siliceous and alkaline waters at work in metamorphic action tend to dissolve away calcareous fossils. Moreover most shells have thin walls, a large part not over a fiftieth of an inch thick; and hence, if the crystalline grains made by metamorphism are even a thirtieth of an inch across, the shell may disappear. Crinoidal stems and disks are among the most persistent of fossils because of their thickness. The shells of Canaan, as Professor Dwight states, sometimes show that under the metamorphic action they were softened and mashed to pieces, coils unwound and left in bits. The columns of a *Solenopora* are less than $\frac{1}{500}$th of an inch in diameter, and should be obliterated with the slightest change.

Further, hydromica schist, even when fine-grained, is a true mica schist—though containing four or five per cent of water and usually some chlorite—as shown by chemical and microscopic analyses. A hydromica schist is in fact as much a metamorphic rock as a mica schist, although the gradations may be indefinite between it and an argillyte. From Mr. Van Hise's investigations (This Journal, xxxi, 453, 1886), we have learned that mica may be made out of feldspar by metamorphic change, and thus we are relieved of the mysterious fact that mica schists had no mica sediments as predecessors. Hence, from the constitution of mica and orthoclase, *a sediment consisting of detrital orthoclase and clay* (kaolin or decomposed feldspar), half and half or thereabouts, *may*, under heat (with moisture) and pressure, *be converted into a hydromica schist, or else a mica schist, containing about the usual proportion of quartz*, this quartz being the silica set free; and more quartz, if the sediment contained quartz grains. And

there is no reason to doubt, in the present state of petrological and metamorphic science, that if detrital augite or hornblende or biotite were present in the sediment, more or less biotite, or chlorite, or garnets, or hornblende might be formed.

Hence with even the metamorphic change producing a hydromica schist, the disappearance of fossils is to be expected, though not always a fact; and that producing a coarse mica schist necessarily exterminates fossils. In conclusion, I believe we may safely regard the Canaan fossils as proof that the limestones and schists of the Taconic system are not older than the Potsdam sandstone. In June last, Professor Dwight discovered another locality of fossils at Canaan, and the locality has afforded *Ophileta* and *Holopea*-like forms, besides others, with numerous small crinoidal disks; and some of the Ophileta-like shells are nearly two inches in diameter. He is at work studying the species and will soon report upon them.

6. *Tertiary Ophiolitic and basic rocks of Scotland and Ireland.*—Signor B. Lotti (Boll. Com. Geol., April, 1886, p. 73) reviews two recent papers of Prof. J. W. Judd: the Tertiary and older peridotites of Scotland (Q. J. G. Soc., xli, 354, 1885), and the Gabbros, dolerites and basalts of Tertiary age in Scotland and Ireland (ib., xlii, 49, 1866), and presents somewhat similar facts from the Tertiary formations of Italy. Mr. Judd shows that the igneous rocks of the Western Isles of Scotland, of Faroe Island and northern Ireland, which are similar and of Tertiary age, include gabbros (olivine-gabbros of some authors), dolerytes, basalt and basalt-glass; that there is a gradual passage from coarse gabbro, of true *granitic* type of texture, to tachylyte or basalt-glass; that porphyritic kinds occur in the several terms of the series down to that of basalt-glass; that unaltered and altered kinds of several of the rocks occur, and that neither differs from similar rocks of pre-Tertiary age; that the altered forms include saussurite-gabbro (having the feldspar changed to saussurite and the augite more or less to foliated hornblende); that the gabbro passes into picryte by the disappearance of the feldspar, into trocholyte by the disappearance of the augite, and into eucryte by the disappearance of olivine; that the gabbros, dolerytes, basalts and tachylytes do not present any essential difference in their bulk-analyses; that, in the incipient stage of change, augite often assumes the foliated structure of diallage and lustre of bronzite or schiller spar, a process which Mr. Judd names *schillerization*, and that it may pass thence, by further change, into serpentine, though the alteration of olivine is the common source of the serpentine.

Signor Lotti cites also the paper of Hague and Iddings with regard to the gradation between granitoid and basaltic forms of the same igneous mass in Nevada. He describes the ophiolitic Tertiary rocks of Italy as intersecting and interlaminated with Eocene strata; as including euphotide (gabbro), diabase (doleryte), and serpentine; the euphotide as labradoritic, or saussuritic (most common), or olivinic, or serpentinous (very common), and

as associated with hypersthenyte, lherzolyte, and granite; the diabase as aphanitic, or microcrystalline, porphyritic, amygdaloidal, or chrysolitic, and by alteration becoming gabbro rosso, and variolitic and uralitized diabase. He observes that these rocks occur in close association, the diabase forming the upper portion of an ophiolitic mass, and the euphotide in intercalated beds or masses; and that the serpentinous change has often penetrated into the enclosed argillaceous sedimentary beds of the Eocene; that the idea of a pre-Eocene age, assumed by some, is wholly opposed by the facts. In the amount of alteration, the region differs from the Scotch and Irish described by Mr. Judd; and the eruptions in Italy were submarine instead of subaerial.

From numerous observations it is shown that the euphotide and diabase are parts of the same eruptive magma, and that the former is simply a result of slower cooling, becoming true granitoid in texture in the deeper portions of the originally liquid mass.

Signor Lotti says that in Italy the term gabbro cannot be used for a labradoritic euphotide, as now common in lithology, because it retains there its original use for a serpentine rock, *gabbro verde* being the unaltered and *gabbro rosso* the altered and reddened. This fact is enough to condemn the term to banishment from science. J. D. D.

7. *Onus probandi left for others.*—The leaving of the *onus probandi* for others is no uncommon occurrence in science. But it has recently been dignified by being presented as a worthy geological method by a distinguished English geologist on a prominent occasion. He opens his discussion, and confidently ends it, with the sentiment that "while admitting the possibility of these identifications [those of schists and gneisses with any of the strata of Palæozoic or later age] the evidence in their favor has been in so many instances proved to be fallacious that the *onus probandi* lies on him who asserts, not on him who denies the identification." This means that, in cases of doubt, one side may be assumed to be true by the self-convinced geologist until the other has been proved true by somebody else. It is a method of dealing in science that is likely to turn out disastrous, not to truth, for others will investigate, but to the positivist who finds comfort in *his* truth however much he may think himself sustained by "all the rules of evidence and reasoning." The same memoir says, in another place: "all attempts to identify large groups of metamorphic rocks with strata of post-Archæan age have proved to be failures." So Professor Bonney thinks. The really progressive geologist—not of "the new school in geology" of and for which he speaks—would reverse this statement and say: The identification of all large groups of metamorphic rocks with strata of Archæan age has not yet been accomplished. This is the precise fact.

Again he says: "It will surprise me if the comparatively late date assigned by some geologists to the marble of Carrara proves

to be correct"—a statement which, in justice to Italian and other investigators, and to right scientific methods, had better have been withheld, and kept in the form of a private doubt, until the author of it had investigated the region; for it is putting his ignorance against others' knowledge in a case where only field-study can decide as to the truth.

The difficult question with regard to the age of metamorphic rocks over the globe has had, in fact, little careful study, and partly because of "settled opinions." Work however is going forward by geologists who are not disposed to avoid the *onus probandi*, and a chronological scheme probably will be finally arrived at based on positive knowledge of the kinds that were made in successive ages. J. D. D.

8. *Preliminary Report upon Petroleum and inflammable Gas of Ohio*, by E. Orton, State Geologist. 76 pp., 8vo. Columbus, O.—Mr. Orton treats of the geology of the petroleum and gas of Ohio, and also of matters of economical interest. The rock yielding the large supplies of these materials in Ohio is the Trenton limestone, in Wood, Hancock and Allen Counties of northwestern Ohio. Borings go down a thousand feet or more below the surface, but not over 50 feet into the Trenton. At Findlay, in this part of Ohio, the Karg well yields 12,000,000 cubic feet of gas a day. Oil and gas are also obtained from the Berea grit, a sandstone of the Subcarboniferous, in eastern Ohio. But its largest gas-well yields only 35,000 cubic feet per day. In some places the overlying sandstones of the Waverly and Coal measures are sparingly productive. Some oil and gas come also from wells in the Devonian shales, but the supply is small. In a very moderate way gas is derived from borings into the glacial drift, and the supply is sometimes sufficient for "household service" and "has been so used for many years at a number of points in Champaign Co., Illinois." At St. Paris, Champaign Co., Ohio, a place 1237 feet above the sea-level, the drill went down 510 feet through drift before reaching solid rock; and at 400 feet passed much vegetable matter, as tree trunks (red cedar) and branches and black soil. Such vegetable deposits have been found at many places in the drift of Ohio, and are the source of the gas the drift occasionally affords.

The Findlay gas was found by Professor C. C. Howard, of Columbus, to contain marsh gas, or light carburetted hydrogen 92·61 p. c., olefiant gas 0·30, hydrogen 2·18, nitrogen 3·61, oxygen 0·34, carbonic acid 0·50, carbonic oxide 0·26, hydrogen sulphide 0·20=100.

9. *A peculiar feature of the Clay-beds on the west bank of the Hudson, 3 miles north of Newburgh.*—These beds are described by Professor Wm. B. Dwight (Trans. Vassar Br. Inst., Poughkeepsie, 1884, '85) as inverted conoidal masses of clay made by the filling of large conoidal depressions in sand-beds. Three conoidal masses of clay have been opened. One of the inverted conoids is elliptical in cross section, 80 by 50 feet at bottom and

150 feet in longest diameter at top; and the depth is 90 to 100 feet. The other two are of like size in the same line parallel with the Hudson, and only a few yards apart. The clay is in regular concentric layers, being deeply concave downward, and is of excellent quality. The sand and gravel beds outside are bent downward at the wall of the cavity; and the wall, or shell, was quite distinct and rather firm. There are a few bowlders in the clay. Professor Dwight supposes that the sand and gravel beds (stratified drift of the Hudson river valley) were excavated by whirlpools, and the conoidal basins thus made; and that these cavities, when the chief current of the stream had become diverted from the place, became gradually filled with clay. Still another peculiar feature is described and figured in this paper, which is not so easily explained.

10. *On the Fossil Flora of the Laramie Series of Western Canada;* by Sir William Dawson, LL.D., F.R.S.—The Laramie series, formerly known as the Lignite Tertiary or Lignitic group, occurs in Canada principally in two large areas west of the 100th meridian and east of the Rocky Mountains, and stretching northward from the United States boundary. These areas are separated from each other by a low anticlinal of Cretaceous beds, over which the Laramie may have extended previously to the later denudation of the region.

These areas may be designated—(1) The Eastern or Souris River and Wood Mountain area; (2) the Western area, extending along the eastern side of the Rocky Mountains, and across the upper waters of the Bow, Red Deer, Battle and North Saskatchewan Rivers.

In the southern part of the District of Alberta it has been found possible to divide the Laramie into three parts, which have been named respectively, in the Reports of the Geological Survey of Canada, (1) the lower or St. Mary River division, (2) the middle or Willow Creek division, and (3) the upper or Porcupine Hill division. Of these the lower and upper contain fossil plants, more especially the latter, and corresponding horizons can be recognized by these in both of the great areas above referred to. The flora of the lower division has a close alliance with that of the Belly River group of the underlying Cretaceous, while that of the upper division is in the main identical with that of the Fort Union group of the United States geologists, as described by Newberry and Lesquereux.

In the eastern area, the lower beds of the Laramie rest on the Fox Hill group of the Cretaceous, and are in turn unconformably overlaid in the Cypress Hills by beds referred by Professor Cope, on the evidence of mammalian remains, to the White River division of the Miocene Tertiary. Thus the geological horizon of the Laramie is fixed by stratigraphical relations as between the upper Cretaceous and lower Miocene formations. The evidence of fossil remains accords with this position. The lower Laramie has afforded reptilian remains of Mesozoic aspect, associated with

fishes and molluscs, some of which are of Eocene types, according to Cope and Whiteaves, and its flora is akin to that of the upper Cretaceous. The upper Laramie has offered a flora so modern in aspect that it has even been regarded as Miocene, though in reality not later in age than the Eocene. The Willow Creek or middle Laramie division may therefore (as suggested by the author in his memoir of last year on the western Cretaceous) be regarded as the transition from the Cretaceous to the Eocene.

The question of the correlation of the Laramie with other formations has been much complicated by the reference, in the United States and elsewhere, of beds holding its flora to the Miocene period, and these difficulties cannot as yet be wholly overcome, though they are gradully being removed. In Canada, since the plants began to be collected and studied there has been little doubt on the subject, and the author now, as heretofore, holds to the correlation with the Laramie flora of the so-called Miocene of Mackenzie River, Alaska, Greenland and Spitzbergen, and believes that they should be regarded as not newer than Eocene.

The greater part of the paper is occupied with the description of the fossil plants of the formation, including those collected in the Eastern area by Dr. Selwyn and Dr. G. M. Dawson, and those obtained from the Western area by the latter, Mr. Weston, Mr. Tyrrell and the author. These include a large number of exogenous trees, all belonging to modern genera, as *Platanus, Corylus, Populus, Salix, Viburnum, Carya, Juglans*, etc. There are also some curious plants allied to the modern trapa or water chestnut, and coniferous trees of the genera *Taxodium, Sequoia* and *Salisburia*, as well as some ferns and equisetaceous plants of much interest, more especially in reference to their geological and geographical distribution.—*Abstract of Paper read to Royal Society of Canada*, May, 1886.

11. *On the Decay of Building Stones;* by T. Egleston (Am. Soc. Civ. Eng., xv, 1886).—In this paper the writer reviews some of the causes of decay affecting building stones, especially such as depend on the removal of an ingredient by solution or decomposition. Many facts of interest are reported. Among the observations he mentions that dolomitic limestones, which in many regions crumble to sand, in the case of monuments as well as in those of the native ledges, owe this to the fact that they are to a large extent mixtures of true dolomite and limestone; and that the limestone, the most soluble portion, is dissolved and removed by percolating carbonated waters.

12. *Geological Studies, or Elements of Geology for High Schools, Colleges, Normal and other Schools;* by Alexander Winchell, LL.D. 514 pp. 12mo, with 367 illustrations. Chicago, 1886. (S. C. Griggs & Co.)—In this work Professor Winchell shows the hand alike of an instructor, a thinker, and a field-observer. He introduces the student to the subject by presenting first a chapter on the drift and some other phenomena over the earth's surface open to ordinary observation, sometimes considered

under the head of Surface Geology. The subject of minerals and rocks is next treated with some detail, and then that of sedimentary erosion, stratification, geological maps, volcanoes, mountains and mountain formation, veins and ores, and the characters of some common fossils. After thus giving the learner some of the general facts of the science, Part II follows, with the title, Systematic Studies. Under it, the chapters treat in succession of lithological, structural, dynamical, paleontological, formational and historical geology. The illustrations of the volume are excellent.

13. *Glacial action in Australia.*—Mr. J. Stirling reported before the Linnæan Society of N. S. Wales, in May, that during a recent visit to Mount Bogong, the highest mountain in Victoria (South Australia) he found erratics, perched blocks, smoothed surfaces and old moraines, affording fresh evidence in favor of glacial action.

14. *Analysis of Biotite* by Edo Claassen (communicated).—The biotite, which is found intimately associated with the magnetite of the Lake Superior Iron Region, occurs compact massive or as an aggregate of small scales. It is dark olive-green or greenish black in color, and has a specific gravity of 2·7. It is easily decomposed by hot hydrochloric or sulphuric acid, leaving the silica in scales. An analysis yielded :

SiO_2	Al_2O_3	Fe_2O_3	FeO	MnO	MgO	K_2O	TiO_2	H_2O	Cl	undecomposed
32·02	20·38	7·15	18·36	0·45	7·84	5·91	2·38	2·71	0·02	0·99=98·21

III. Botany.

1. *Lloyd's Drugs and Medicines of North America.*—This great repertory of the materia medica and pharmacy of the flora of North America has now promptly entered upon its second volume, in its June number, devoted to *Liriodendron* and some of the species of *Magnolia.* Eighteen pages and one fine plate are given to the tulip-tree. A. G.

2. *Cypripedium arietinum* in the mountains of China is a notable addition to an already very considerable list of disjoined species, divided between Eastern North America and Eastern Asia, with prolongation in the Himalayas. It is M. Franchet who announces this instance in *Bull. Soc. Bot. de France*, vol. xxxiii, p. 206. Almost as unexpected as the instance itself is M. Franchet's accompanying announcement of it as a wholly unparalleled case of such distribution. Not to mention the recently accrued instance of *Liriodendron*, there is the very old one of *Phryma*, and a good many more of the same character. A. G.

3. *Index to the Botanical Gazette.*—Along with the July number of this periodical we receive the index to volumes i to x (1875–1885), filling 29 pages. It is a triple index, viz: of subjects, of authors of articles, and of illustrations. It is not issued as a part of the July number, which is a full one of 36 pages, and is therefore a free gift of the editors and publishers, Professors Coulter, Arthur and Barnes. The improvement of this useful

journal in typographical appearance and dress, as well as in matter and handling, is as great as its increase in size in this its eleventh year. It is wonderful that it can give so much for the subscription price of two dollars a year. A. G.

4. *The Cayuga Flora:* Part I. *A Catalogue of the Phænogamia growing without cultivation in the Cayuga Lake Basin;* by WILLIAM K. DUDLEY. Ithaca, 1886. 8vo., pp. 132 and an index.—This is the first part of vol. xi of the Bulletin of Cornell University, which is now revived in affectionate and revered memory of the late Professor Hartt, who originated it in the year 1874. It promises to be a worthy continuation of a series nobly begun, and Professor Dudley has evidently done his work conscientiously and well. The plan, the typography, and the treatment are to be commended. The introductory account of the Cayuga flora, its topography (illustrated by two maps), statistics and the history of exploration of the district are quite interesting and would tempt us to some detailed notice, if time and space permitted.

The reference to John Bartram as the first botanical explorer of the region recalls a fact, recorded in this Journal a few years ago, which might have been noticed under *Selinum Canadense.* For this is the "*Athamantha Chinensis*" of Linnæus; and the solution of his riddle, "Habitat · · · *Chinensem dixit Barthram*, qui semina misit ex Virginia," is this. Bartram picked the seed probably in the neighborhood of Ithaca and sent it to Linnæus as from the "Genessee country" (the general name of that part of New York in those days), and Linnæus, or the Upsala gardener, somehow mistook Bartram's *Genesee* for *Chinesé.* A. G.

5. *Catalogue of the Plants in the Herbarium of the College of Science, Imperial University, Tokyo, Japan.* P. Maruya & Co. 2546 (1886).—A handsome volume of 287 pages, in small octavo, with a few pages of corrections, with an explanatory preface in Japanese, the botanical names of the species and authorities in Roman type, the popular names and other matter in the Japanese character. The name of the compiler (evidently no mean botanist) is not given. We receive the interesting volume "with the compliments of H. Watanabe, President of the University," to whom we would offer thanks and congratulations. It is interesting to receive upon the same day these contributions to botany from the Cornell and from the Tokyo Universities. A. G.

IV. MISCELLANEOUS SCIENTIFIC INTELLIGENCE.

1. *The Races of Britain*, a Contribution to the Anthropology of western Europe; by JOHN BEDDOC. Bristol, England. 272 pp. 8vo, 1885. (Trubner & Co., London.)—The title of this work hardly gives an idea of its scope. It is a learned discussion of the facts connected with western Europe as well as British races, prehistoric and historic, Roman, Saxon, Frisian, Germanic, Danish, Norman, etc., on the origin of the race peculiarities in Britain.

2. *Estudios de Meteorologia Comparada*, por MARIANO BARÇENA y MIGUEL PÉREZ. Vol. I, 438 pp. 8vo. Mexico, 1885.—This government publication on Mexican meteorology contains the results of the observations made by the Central and other Meteorologico-magnetic Observatories of Mexico. It is the first of a series of volumes, and covers the months of January to April, 1881.

3. *Monument to Horace-Benedict de Saussure.*—H. B. de Saussure, the eminent meteorologist, geologist, and explorer of the Alps, died in the closing year of last century. A circular letter signed by Professor A. Favre of Geneva states that it is proposed to erect a monument to his memory to "be placed at the foot of Mont Blanc, whose lofty summit the illustrious savant reached," not far from the Col du Géant,—where amidst snow and ice he was encamped for sixteen days. The inauguration is planned for the 3d of August of 1887, the centenary of his ascent of Mont Blanc. The character of the monument will depend on the amount that may be received from the admirers of the intrepid explorer.

4. *Biographies of American Naturalists*, III. *Publications relating to Fossil Invertebrates*, by J. BELKNAP MARCOU, Bull. U. S. Nat. Mus., No. 30. 334 pp., 8vo. Washington, 1885.—This number of the very valuable series prepared by Mr. Marcou contains lists of the publications on fossil invertebrates, and of all species described in the publications, by the following authors: F. B. Meek, C. A. White, C. D. Walcott, J. W. Bailey, J. D. Dana, C. G. Ehrenberg, James Hall, A. Heilprin, A. Hyatt, J. Marcou, J. S. Newberry, D. D. Owen, J. Schiel, B. F. Shumard, R. P. Whitfield, T. N. Nicollet and H. A. Prout.

5. *La Terre des Merveilles; Promenade au Parc National de L'Amerique du Nord;* par JULES LECLERCQ. 384 pp. 16mo, with several plates of the geysers. Paris, 1886 (Hachette & Co.).—A popular work in French on the Yellowstone Park, the facts and figures derived from the reports of Hayden's Expedition.

OBITUARY.

1. Dr. HERMANN ABICH, the distinguished Austrian geologist and mineralogist, died at Vienna on the first of July. He was born in Berlin on the 11th of December, 1806. He commenced his publications in 1831, with a paper on the composition of the species of the spinel family. His explorations of Etna and Vesuvius were followed by various papers and by the publication in both French and German of a folio atlas entitled "Vues illustratives de quelques phénomènes géologiques, prises sur le Vésuve et sur L'Etna," published in 1837 and his "Geologische Beobachtungen über die vulkanischen Erscheinungen" of 1841. He was long professor of Mineralogy at Dorpat and made explorations in the Caucasus and Northern Persia, and a large work entitled "Geologische Forschungen in den Kaukasischen Ländern" was in course of publication at the time of his death, only the first part having appeared. He was an able worker in science of great energy, and continued so to the closing year of his life.

APPENDIX.

Catalogue of the Collection of Meteorites in the Peabody Museum of Yale College.

METEORIC STONES.

	Date of Fall.	Locality and Catalogue Number.	Weight in grams.	
			Largest mass.	Total.
1	1492, Nov. 16	Ensisheim, Elsass, Germany (1).	13	18
2	1790, July 24	Barbotan, Landes, France (55).	15	15
3	1798, Dec. 13	Benares, Bengal, India (2).	1	1
4	1803, April 26	L'Aigle, Orne, France (3).	902	902
5	1807, Dec. 14	Weston, Connecticut (4).	14,625	15,300
6	1808, April 19	Parma (Borgo San Donino), Italy (5).	10	10
7	1808, May 22	Stannern, Moravia (6).	76	107
8	1810, Nov. 23	Charsonville, near Orléans, France (7).	9	9
9	1811, July 8	Berlanguillas, near Burgos, Spain (8).	14	14
10	1812, April 15	Erxleben, Magdeburg, Prussia (48).	13	13
11	1812, Aug. 5	Chantonnay, Vendée, France (9).	39	39
12	1814, Feb. 15	Bachmut, Ekaterinoslaw, Russia (10).	2	2
13	1814, Sept. 5	Agen, Lot-et-Garonne, France (61).	7	7
14	1815, Feb. 18	Durala, Punjaub, India (11).	3	3
15	1818, Aug. 10	Slobodka, Smolensk, Russia (12).	2	2
16	1819, June 13	Jonzac, Charente infér., France (13).	2	2
17	1822, Nov. 30	Futtehpur, India (14).	36	36
18	1822–23,	Umballa, Punjaub, India (15).	1	1
19	1825, Feb. 10	Nanjemoy, Maryland (16).	897	897
20	1825, Sept. 14	Honolulu, Sandwich Islands (17).	577	577
21	1827, May 9	Nashville (Drake Creek), Tennessee (18).	422	422
22	1828, June 4	Richmond, Virginia (19).	305	305
23	1829, May 8	Forsyth, Monroe Co., Georgia (20).	132	132
24	1831, July 18	Vouillé, near Poitiers, France (21).	5	5
25	1838, April 18	Akburpur, Saharanpur, India (22).	1	1
26	1838, June 6	Chandakapur, Berar, India (23).	41	41
27	1838, Oct. 13	Cold-Bokkeveldt, Cape of Good Hope (24).	96	109
28	1839, Feb. 13	Little Piney, Pulaski Co., Missouri (25).	24	24
29	1841, June 12	Château Renard, Loiret, France (26).	91	91
30	1842, April 26	Milena, Warasdin, Croatia (63).	7	7
31	1843, June 2	Utrecht, Blaauw-Kapel, Holland (27).	4	4
32	1843, Mar. 25	Bishopville, South Carolina (28).	213	213
33	1846, May 8	Monte Milone, Macerata, Italy (29).	3	3
34	1846, Aug. 14	Cape Girardeau, Missouri (67).	1,478	2,058
35	1847, Feb. 25	Linn County, Iowa (30).	651	1,046
36	1849, Oct. 31	Cabarras County (Charlotte), N. Carolina (31).	231	231
37	1850, Nov. 30	Shalka, Bancoorah, India (32).	1	1
38	1851, April 17	Gütersloh, Westphalia (33).	4	4

METEORIC STONES—*Continued.*

	Date of Fall.	Locality and Catalogue Number.	Weight in grams.	
			Largest mass.	Total.
39	1852, Jan. 23	Nellore (Yatoor), Madras, India (34).	27	47
40	1852, Sept. 4	Mezö-Madaras, Transylvania (35).	20	20
41	1853, March 6	Segowlie, Bengal, India (36).	46	46
42	1855, May 11	Oesel Island, Livonia, Russia (37).	6	6
43	1855, Aug. 5	Petersburg, Lincoln Co., Tennessee (49).	15	15
44	1857, Feb. 28	Parnallee, Madras, India (38).	945	2,370
45	1858, Dec. 9	Aussun, Haute Garonne, France (59).	18	18
46	1859, Mar. 28	Harrison County, Indiana (39).	17	17
47	1860, May 1	Guernsey County (New Concord), Ohio (40).	6,718	6,718
48	1860, July 14	Dhurmsala, Punjaub, India (68).	28	28
49	1860, Found	Newton County, Arkansas (52).	7	7
50	1861, May 12	Butsura, Bengal, India (41).	92	92
51	1863, June 2	Buschhof, Kurland, Russia (42).	22	22
52	1863, Aug. 8	Pillistfer, Livonia, Russia (43).	12	14
53	1863, Dec. 7	Tourinnes-la-Grosse, Tirlemont, Belgium (64).	4	4
54	1863–64, Found	Tomhannock Creek, Rensselaer Co., N. Y. (75).	15	15
55	1864, April 12	Nerft, Kurland, Russia (44).	48	48
56	1866, June 9	Knyahinya, Unghvár, Hungary (60).	41	65
57	1868, Jan. 30	Pultusk, Poland (45).	176	364
58	1868, Nov. 27	Danville, Alabama (51).	11	11
59	1868, Dec. 5	Frankfort, Franklin Co., Alabama (46).	185	255
60	1869, Jan. 1	Hessle, near Upsala, Sweden (54).	39	39
61	1869, May 5	Krähenberg, Zweibrücken, Palatinate (50).	2	2
62	1869, May 22	Cléquérec, Brittany, France (47).	8	8
63	1869, Found	Near Salt Lake City, Utah (69).	875	875
64	1871, May 21	Searsmont, Waldo Co., Maine (58).	10	10
65	1872, Found	Waconda, Mitchell Co., Kansas (62).	51	51
66	1873, June	Jhung, Punjaub, India (72).	16	16
67	1874, May 14	Castalia, Nash Co., North Carolina (70).	248	248
68	1875, Feb. 12	Iowa County, Iowa (56).	11,960	35,719
69	1876, Dec. 21	Rochester, Fulton Co., Indiana (58).	15	15
70	1877, Jan. 3	Warrenton, Warren Co., Missouri (57).	106	260
71	1877, Oct. 13	Soko-Banja, Servia (66).	2	2
72	1878, Nov. 29	Rakowka, Tula, Russia (65).	·5	·5
73	1879, May 10	Estherville, Emmet Co., Iowa (74).	41,960	48,175
74	1882, Feb. 3	Bare, Möcz, Transylvania (71*a*).	50	50
		Möcz, Transylvania (71*b*).	104	104
75	1882, Feb. 16	Alfianello Brescia, Italy (73).	140	175

Meteoric Irons.

	Date of Discovery.	Locality and Catalogue Number.	Weight in grams.	
			Largest mass.	Total.
76	1751, May 26 Fall	Agram, Hraschina, Croatia (1).	3	3
77	1751	Steinbach, Saxony (2).	2	2
78	1749	Krasnojarsk, Siberia (3).—*Pallas Iron.*	1,327	1,780
79	1784	Toluca, Xiquipilco, Mexico (4).	880	900
80	1793	Cape of Good Hope, South Africa (5).	8	12
81	1804	La Descubridora, San Luis Potosi, Mexico (58).	195	195
82	1811	Elbogen, Bohemia (7).	8	8
83	——	Colombia, S. A. (51). ?	57	57
84	1814	Red River, Texas (6).	—	740Kilos
85	1814	Bitburg, Eifel, Prussia (8).	63	63
86	1814	Lenartó, Saros, Hungary (9).	120	120
87	1818	Lockport (Cambria), New York (10).	3,156	3,156
88	1819	Burlington, Otsego Co., New York (11).	738	738
89	1820	Guilford County, North Carolina (12).	20	20
90	1824	Santa Rosa (Tocavita), New Granada (79).	2	2
91	1827	Atacama, Bolivia, South America (13).	178	278
92	1827	Newstead, Roxburghshire, Scotland (44).	96	96
93	1829	Bohumilitz, Prachin, Bohemia (14).	37	37
94	1832	Walker County, Alabama (23).	357	357
95	1834	Scriba, Oswego Co., New York (19).	173	173
96	1834	Claiborne, Clarke Co., Alabama (15).	64	64
97	1835	Asheville (Black Mountain), N. Carolina (20).	15	15
98	1839	Putnam County, Georgia (16).	294	356
99	1840	Sevier Iron, Cocke Co., Tennessee (17).	935	935
100	1840	Tarapaca, Peru (76).	17	17
101	1840	Carthage, Smith Co., Tennessee (24).	104	104
102	1840	Arva (Szlanicza), Hungary (18).	826	1,126
103	1845	DeKalb County (Caryfort), Tennessee (21).	61	61
104	1845	Madagascar, St. Augustine's Bay (22).	7	7
105	1846	Tula, Netschaëvo, Russia (69).	31	31
106	1847	Seeläsgen, Brandenburg, Prussia (25).	174	174
107	1847	Rittersgrün, Saxony (71).	23	23
108	1849	Chesterville, Chester Co., S. Carolina (27).	758	758
109	1850	Pittsburg, Pennsylvania (26).	213	213
110	1850	Schwetz, Prussia (28).	256	256
111	1850	Salt River, Kentucky (29).	985	985
112	1850	Ruff's Mountain, Lexington Co., N. C. (30).	536	536
113	1850	Seneca Falls, Cayuga Co., New York (31).	30	30
114	1852	Poplar Camp, Cranberry Plantation, Va. (62).	21	21
115	1853	Tazewell, Claiborne Co., Tennessee (34).	418	418
116	1853	Union County, Georgia (65).	15	15
117	——	Chihuahua, Mexico (49).	51	51
118	1854	Madoc, Canada (35).	26	26
119	1854	Tucson, Arizona (37).	158	158

METEORIC IRONS—*Continued.*

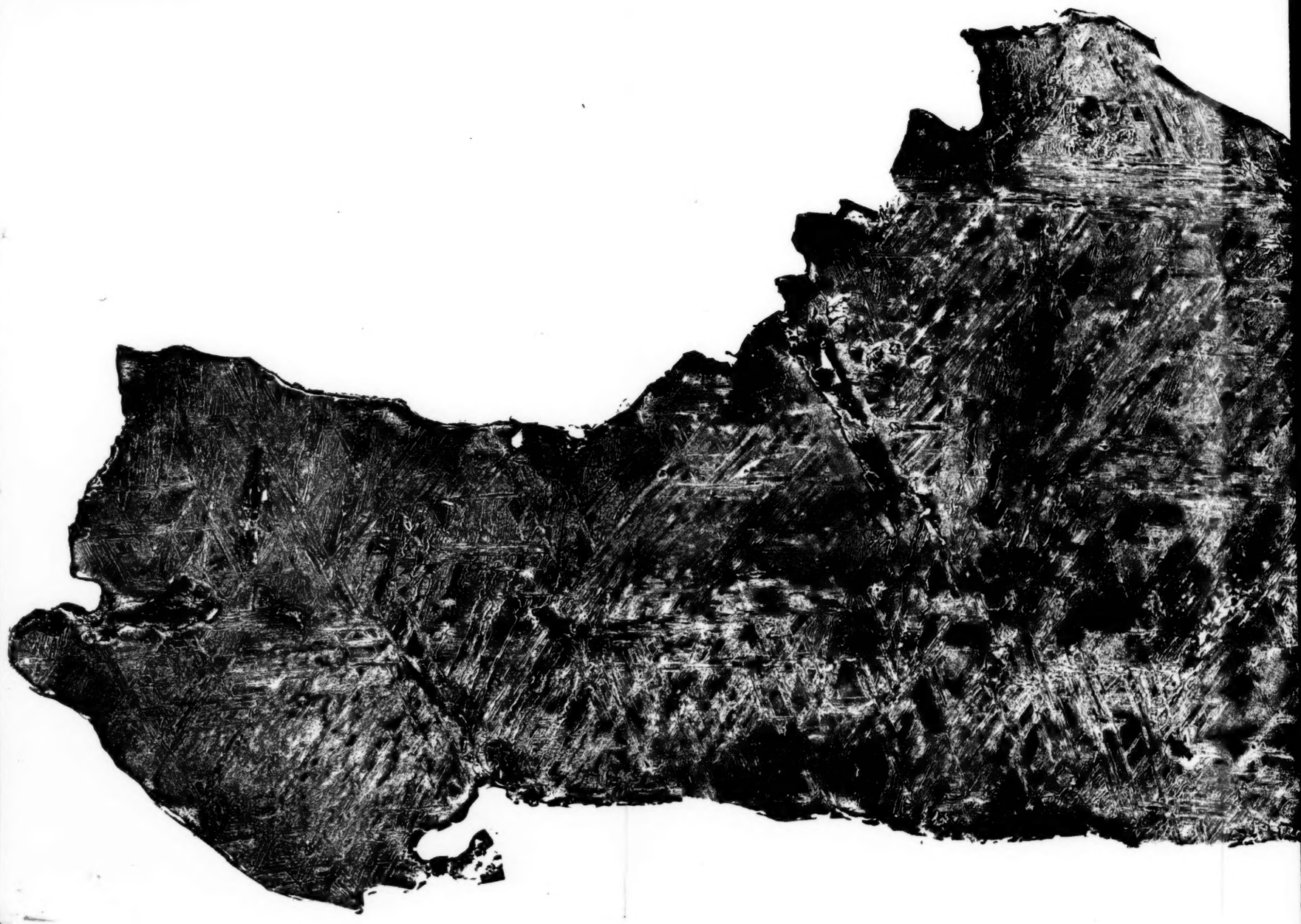
	Date of Discovery.	Locality and Catalogue Number.	Weight in grams.	
			Largest mass.	Total.
120	1856, 1873	Jewell Hill, Madison Co., N. Carolina (41, 61).	5,610	5,655
121	1856	Fort Pierre, Dakota (43).	343	343
122	1856	Nelson County, Kentucky (40).	112	112
123	1856	Denton County, Texas (42).	66	66
124	1856	Orange River, South Africa (39).	27	27
125	1856	Hainholz, Westphalia (38).	8	8
126	1857	Octibbeha County, Mississippi (36).	1	1
127	1858–59	Augusta County, Virginia (77).	885	885
128	1860	Lagrange, Oldham Co., Kentucky (60).	46	46
129	1860	Lion River, Gt. Namaqualand, S. Africa (33).	40	40
130	1861	Robertson County, Tennessee (45).	115	115
131	1862	Sierra de Chaco, Atacama (72).	39	39
132	1862	Colorado River, La Paz, New Mexico (46).	11	11
133	1863	Dakota (48).	4	4
134	1863	Russell Gulch, Gilpin Co., Colorado (55).	126	126
135	1863	South East Missouri (47).	68	68
136	1866	Bear Creek, near Denver, Colorado (53).	151	151
137	1866	Frankfort, Franklin County, Kentucky (54).	37	37
138	1867	Bates County, Missouri (73).	970	970
139	1867	Santa Catarina, Morro do Ricio, Brazil (67,75).	800	1,015
140	1867	Arizona, exact locality unknown (52).	42	42
141	1868	Coahuila, Bolson de Mapini, Mexico (64).	1,508	2,810
142	1869	Washington Co. (Trenton), Wisconsin (57).	65	65
143	1869	Shingle Springs, Eldorado Co., California (59).	932	932
144	1872	Nenntmannsdorf, Saxony (66).	47	47
145	1879	Ivanpah, San Bernardino, California (70).	4	4
146	1880	Lexington, South Carolina (68).	49	49
147	1884	Glorieta Mt., near Canoncito, New Mexico (78).	2,840	3,970

The last catalogue of the meteorites preserved in the Mineralogical Collection of Yale College was published in 1869. At that time the total number of catalogued specimens, including stones and irons, amounted to 102. Since then the collection has increased about one-half in number, and very largely also in weight, though hardly in the same proportion. The total weight of the stones is now about 117 kilos, of the irons 772 kilos, or in all 889 (about 1956 pounds).

The largest specimen in the present collection is the iron from the Red River, Texas, weighing 740 kilos (1635 lbs.) the history of which is well known. Next to this the most notable falls represented are those of Feb. 12, 1875, in Iowa County, Iowa, and of May 10, 1879, in Emmet County, Iowa. Of the first the collection contains 20 stones, eight of them weighing more than a kilo and the largest weighing about 12 kilos. Of the second there are nearly six hundred complete specimens, the largest weighing 42 kilos (nearly 100 lbs.), the small stones ranging from those weighing a pound down to those of the size of a pea. This Emmet County meteorite is here included among the stones, although it is properly intermediate between the ordinary meteoric stones and the irons. Other large stones in the collection are those of Weston, Connecticut and Guernsey County, Ohio. The stones of Cape Girardeau, Mo., and Salt Lake City, Utah, are at this time represented in this collection only.

It is desired to increase the collection as opportunity offers and make it as complete as possible. Any communications having this end in view, either by gift, purchase or exchange, may be addressed to the writer, the Curator of the Collection, at New Haven, Connecticut.

Aug. 10, 1886. EDWARD S. DANA.



LARGEST SECTION OF MASS No. 1.

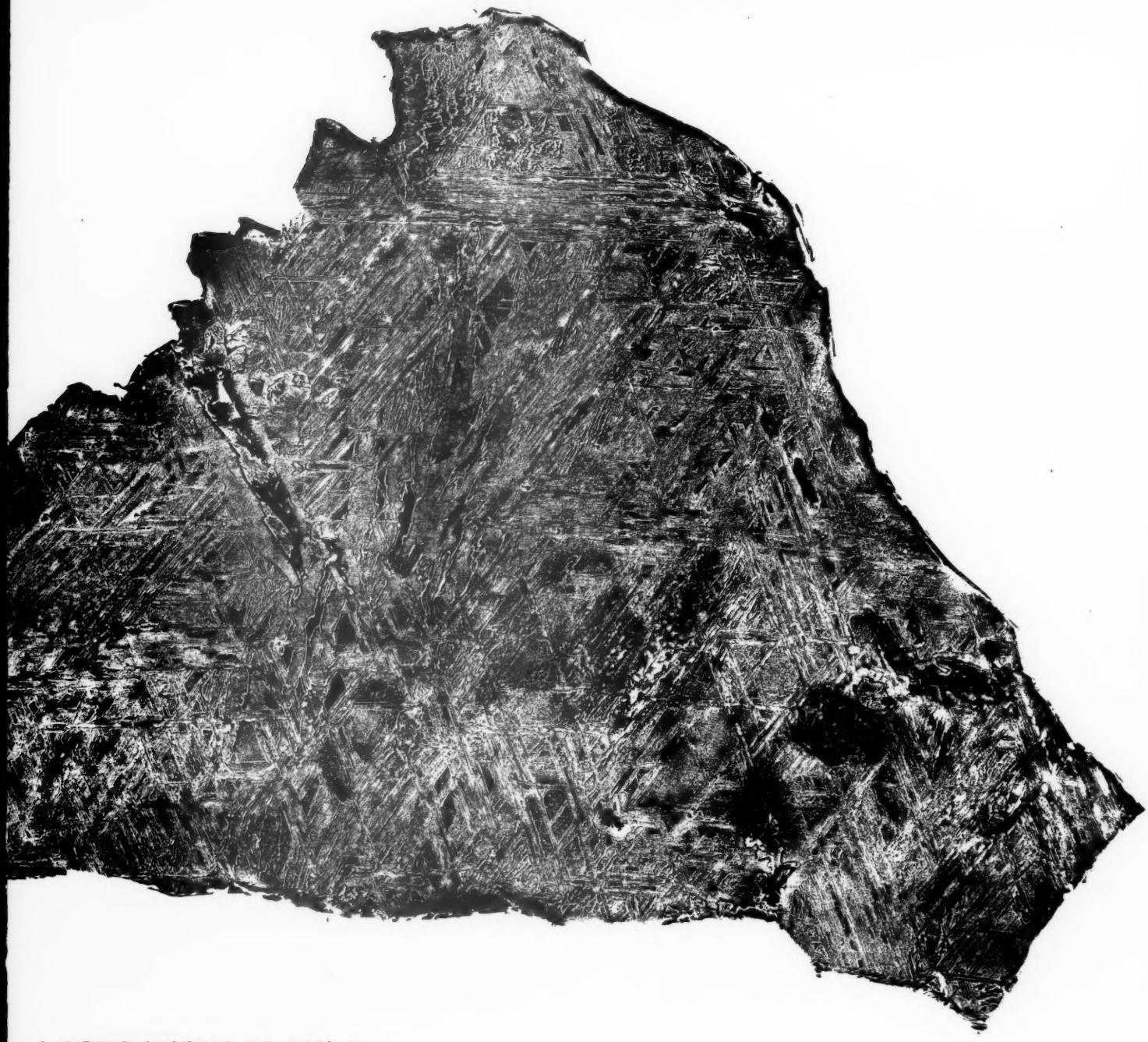
METEORITE

(EXACT SIZE).

FROM GLORIETA MOUNTAIN, SANTA FÉ CO., NEW MEXICO.

GEORGE F. KUNZ.

PRINTED FROM AN ELECTROTYPE MADE BY DEPOSI



LARGEST SECTION OF MASS No. 1.

METEORITE

(EXACT SIZE).

ORIETA MOUNTAIN, SANTA FÉ CO., NEW MEXICO.

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